Amplifying the power of Art in STEAM: A descriptive analysis of art through design attributes in STEAM activity system

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Abstract

The purpose of this study is to highlight the importance of 'Art' within the STEAM framework by enhancing instructional processes in both art and design, and science academic silos, thereby enriching the principles of Education for Sustainable Development (ESD). Despite being a vital component of STEAM framework, 'Art' is often undervalued by students and some lecturers in science departments within Uganda's higher education institutions. Using a narrative research design, this study involved conducting interviews and reviewing documents to gain a deep understanding of the lived experiences of purposively selected lecturers and students from both art and design and science disciplines regarding the role of 'Art' in STEAM education. The findings revealed that most students and lecturers in science academic silos perceive 'Art' as an unimportant subject with minimal relevance to science. In contrast, those from art and design disciplines recognized art through design as crucial for enhancing creative thinking capabilities in science fields. The study concluded that there is a significant lack of reflective understanding among science students and lecturers about the potential of 'Art' within STEAM. Art, through design, promotes a 'dialogic' approach that fosters organic linkages in problem-solving processes, a critical element that could benefit both academic domains. The study recommends fostering internal cross-pollination of knowledge by encouraging students to enrol in courses across both art and design and science disciplines. This would not only enhance students' thinking capabilities but help them appreciate how these disciplines can complement each other, to promote mutual appreciation and collaboration, thereby supporting the STEAM education system and the principles of Education for Sustainable Development (ESD).

Key words: STEAM, Design, SDGs, Education for Sustainable Development (ESD), Art

INTRODUCTION

Higher institutions of learning in Uganda and beyond have strategically advocated for student-centered learning approaches. These approaches traditionally have often been confined within distinct academic silos, limiting cross-disciplinary interaction. However, effective learning should transcend these barriers, enabling information cross-pollination beyond distinct academic silos.

The advent of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) education model has enhanced pedagogical activities in the teaching space. Despite its potential, the practical application of STEAM within faculties, schools, and departments has not received sufficient attention. In many instances, STEAM remains confined to specific academic bubbles, particularly within the science disciplines, which often marginalizing the 'Arts' component in their learning journeys. Yet, the goal of education is to impart knowledge and skills that nurture learners' innovative capacities. This narrow focus undermines the holistic goal of education, which is to impart knowledge and skills that foster innovative capacities in learners.

Achieving this goal requires educational strategies that empower learners to make informed decisions and take responsible actions. In alignment with Sustainable Development Goal 4 (SDG4), which aims to "ensure that all learners acquire the knowledge and skills needed to promote sustainable development" by 2030 (Leicht, Heiss & Byun, 2018), Uganda's education system has progressed in embedding the principles of Education for Sustainable Development (ESD) principles into academic programs.

UNESCO (2014) defines ESD as education that enables individuals to acquire the knowledge, skills, attitudes, and values necessary for a sustainable future. López-Alcarria, Olivares-Vicente, & Poza-Vilches (2019) emphasize that ESD requires the creation of interactive, learner-centered teaching and learning environments. It demands an action-oriented, transformative pedagogy that supports self-directed learning, participation, and collaboration. ESD calls for problem-orientation, inter- and trans-disciplinarity, and the integration of formal and informal learning to develop key sustainability competencies. Various educational approaches—such as active learning, reflective learning, collaborative learning, experiential learning, problem-based learning, and interdisciplinary learning—align with ESD principles to enhance the teaching and learning process.

In this context, many higher institutions in Uganda, such as Kyambogo University and Makerere University, have adopted educational strategies that promote student-centered learning. These strategies foster self-directed learning and collaboration, inter- and trans-disciplinarity, enabling learners to acquire holistic and sustainable learning experiences. However, such collaboration

and interdisciplinarity are often more evident in grant research proposals than in internal interactions between departments, faculties, schools, and colleges during teaching and learning processes.

Despite logistical challenges hindering the smooth implementation of student-centered learning, this strategic direction is rooted in the capacity of learning systems to provoke independent reasoning, problem-solving, and critical thinking (Froyd & Simpson, 2008). Student-centered learning, according to Brown (2008), McCombs & Whistler (1997), and Weimer (2002), is based on the constructivist philosophy of teaching, where learners acquire knowledge through doing and experiencing rather than relying solely on the teacher's expertise (Brown, 2008; Olusegun, 2015). From a social constructivist perspective, knowledge is constructed individually and collectively through an active process of linking new ideas with existing knowledge (Kelly, 2012; Spivey, 1997; Polkinghorne, 1992).

Instructional design processes, which involve mental activities generating intellectual entities, ensure that all important information is considered in the context of instructional challenges. To enhance instructional processes that incorporate inter- and trans-disciplinarity, the STEAM instructional approach was developed. This approach weaves the complex tapestry of learning into a comprehensive framework encompassing various academic fields to promote sustainable development.

The STEAM activity system provides access points for students to embrace collaboration, engage in experiential learning, and apply problem-solving approaches. It integrates elements of science, technology, engineering, art, and mathematics in the learning process. The effectiveness of STEAM as an instructional design approach depends on how well these diverse elements are integrated. Poor integration can result in learners failing to grasp how each individual academic field contributes to the STEAM activity system.

Statement Problem

In Uganda and beyond, many higher learning institutions have embraced student-centered learning approaches in theory, yet practical implementation across faculties, schools, and

departments remains inconsistent. Despite efforts to promote Science, Technology, Engineering, Arts, and Mathematics (STEAM) education model, some academic silos within these institutions show moderate adoption, with particular disregard for the 'Art' component. This neglect is especially prevalent among science-focused departments where 'Art' is often considered irrelevant to students' learning journeys.

This scholarly work aims to explore and emphasize the role of 'Art' within the STEAM education framework, particularly through its design aspects, to enhance productivity in instructional processes. By highlighting the creative capabilities of 'Art' within the STEAM activity system, this study seeks to enrich principles of Education for Sustainable Development (ESD).

MATERIALS AND METHODS

This study adopts a social constructivist stance, focusing on the role of social processes in the construction of meaning. It employs a qualitative narrative research design to deeply explore the lived experiences of lecturers and students in both science and Art and Design disciplines regarding the integration of 'Art' within the STEAM education model during teaching and learning processes.

Participants were purposively selected to include students from the engineering department, participants from the art and design field, and lecturers from their respective departments. Semi-structured interviews were conducted to investigate their perceptions and experiences concerning the perception and application of 'Art' through design within the STEAM framework in educational contexts. In addition to interviews, relevant documents were reviewed to supplement the understanding of how the STEAM teaching model is currently utilized within educational contexts.

RESULTS AND DISCUSSION

Findings

Through narrative research design the study gained insights into perceptions of students and lectures in both art and design and science academic silos about the 'Art' under STEAM education model. Past experiences and perception about art has continued to inform today's scholars most especially those in science disciplines.

Lectures in science disciplines who participated in the study acknowledged that art is inconsequential to their science academic disciplines in that using STEAM learning model Art is inconsequential in their learning processes. Students in the same academic silos responded that art in Uganda has been widely considered trivial, where it stems from their parents who rejected the art talent of their children even when they show poor attitude for science subjects so they do not see how art can aid their learning processes.

Furthermore, many student respondents noted that traditionally art is seen as less intellectual, and even at secondary education, art was being viewed as easy subject without fear of entering a laboratory or complex formulas therefore, adoption of 'art' in their thinking process is inconsequential. Some senior lecturers in science discipline cited the president Museveni's remarks on championing of science disciplines at the expense of art disciplines as clear evidence that art is secondary in country's development process. Respondents brought an argument that they do not see or envisage where drawing, painting, sculpture can support science disciplines, a mindset that led some senior lecturers in science Siros replace the 'A' of Art under STEAM to 'A' of Agriculture.

On the issue of Art through design under STEAM, respondents in science discipline acknowledged that design is a broad discipline that in science disciplines there are various design protocols followed, and that through design there could be a connection between the art and science.

On the other hand, Art and design students and lectures acknowledged that art and design under STEAM can provide an opportunity to explore concepts and theories in a more engaging way, merging life learning skills with comprehension of principles and practice.

Respondents noted that arts enable inspiration and novelty as well as the development of cognitive and social growth. Lecturers who participated in the study further stated that Art-based

pedagogy focuses on process-oriented and reflective experiences and draws on a broad range of applied theatrical strategies which can develop learners' creativity, abilities, and aesthetic awareness. That the adoption of 'ART' under STEAM could go a long way to improve productivity and knowledge cross-pollination.

Students in art and design discipline noted that by engaging deeper in art and design curriculum they acquire more practical oriented skills, develop stronger attention to detail and better hand-eye coordination.

Some lecturers view STEAM as an opportunity to share knowledge in that by introducing art projects into a science class could fuel students better understand scientific concepts. In that, by creating drawings, students can visualize what would normally be a very complex subject. Further, stated that creativity is a central component of every art and design field. Allowing students to explore their creativity help them improve their critical thinking skills. Additionally, lecturers asserted that art and design education enable students learn how to think outside the box, which positively impact their ability to solve complex science or mathematical problems which was acknowledge as a core aspect of STEAM education model. And lastly, lecturers specified that creative thinking skills precipitates innovation and allow students the freedom to explore different paths to a solution.

On the issue of Art through design under STEAM, respondents from art and design noted through design that it would go a long way to provide creative and qualitative design thinking process to the STEAM platform.

Through narrative research design, the study gained insights into the perceptions of students and lecturers in both art and design and science academic silos about the role of 'Art' under the STEAM education model. Past experiences and perceptions about art have continued to influence today's scholars, particularly those in science disciplines.

Lecturers in science disciplines who participated in the study acknowledged that art is inconsequential to their science academic disciplines, stating that using the STEAM learning model, art is irrelevant to their learning processes. Students in the same academic silos responded that in Uganda, art has been widely considered trivial. This perception stems from their parents,

who rejected their children's art talent even when they showed a poor attitude towards science subjects. Consequently, these students do not see how art can aid their learning processes.

Furthermore, many student respondents noted that traditionally, art is seen as less intellectual. Even at the secondary education level, art is viewed as an easy subject without the fear of entering a laboratory or dealing with complex formulas. Therefore, the adoption of 'art' in their thinking processes is considered inconsequential. Some senior lecturers in science disciplines cited President Museveni's remarks on championing science disciplines at the expense of art disciplines as clear evidence that art is secondary in the country's development process. Respondents argued that they do not see or envisage how drawing, painting, or sculpture can support science disciplines. This mindset led some senior lecturers in science silos to replace the 'A' for Art in STEAM with the 'A' for Agriculture.

On the issue of art through design under STEAM, respondents in science disciplines acknowledged that design is a broad discipline. In science disciplines, various design protocols are followed, and through design, there could be a connection between art and science.

On the other hand, art and design students and lecturers acknowledged that art and design under STEAM can provide an opportunity to explore concepts and theories in a more engaging way, merging life learning skills with the comprehension of principles and practices. Respondents noted that the arts enable inspiration and novelty, as well as the development of cognitive and social growth. Lecturers who participated in the study further stated that art-based pedagogy focuses on process-oriented and reflective experiences and draws on a broad range of applied theatrical strategies, which can develop learners' creativity, abilities, and aesthetic awareness. They asserted that the adoption of 'ART' under STEAM could significantly improve productivity and knowledge cross-pollination.

Students in the art and design disciplines noted that by engaging more deeply in the art and design curriculum, they acquire more practical skills, develop stronger attention to detail, and better hand-eye coordination. Some lecturers view STEAM as an opportunity to share knowledge, suggesting that introducing art projects into a science class could help students better understand scientific concepts. By creating drawings, students can visualize complex subjects. Further, they stated that creativity is a central component of every art and design field. Allowing

students to explore their creativity helps them improve their critical thinking skills. Additionally, lecturers asserted that art and design education enable students to learn how to think outside the box, which positively impacts their ability to solve complex science or mathematical problems. This was acknowledged as a core aspect of the STEAM education model. Lastly, lecturers specified that creative thinking skills precipitate innovation and allow students the freedom to explore different paths to a solution.

On the issue of art through design under STEAM, respondents from art and design noted that design would provide creative and qualitative design thinking processes to the STEAM platform.

Through a narrative research design, this study gained insights into the perceptions of students and lecturers in both art and design and science academic silos regarding the role of 'Art' within the STEAM education model. Past experiences and perceptions about art have continued to influence today's scholars, particularly those in science disciplines.

Lecturers in science disciplines who participated in the study acknowledged that art is inconsequential to their academic fields. They argued that within the STEAM learning model, art does not contribute significantly to their learning processes. Similarly, students in these academic silos noted that in Uganda, art is widely considered trivial. This perception often stems from parents who reject their children's interest in art, even when they show poor attitudes towards science subjects. Consequently, these students do not see how art can aid their learning processes.

Furthermore, many student respondents observed that traditionally, art is seen as less intellectual. Even at the secondary education level, art is viewed as an easy subject that does not involve the fear of entering a laboratory or dealing with complex formulas. Therefore, they consider the adoption of art in their thinking processes to be inconsequential. Some senior lecturers in science disciplines cited President Museveni's remarks on prioritizing science disciplines over art as clear evidence that art is secondary in the country's development process. Respondents argued that they do not see how drawing, painting, or sculpture can support science disciplines. This mindset has led some senior lecturers in science silos to replace the 'A' in STEAM from Art to Agriculture.

On the issue of art through design under STEAM, respondents in science disciplines acknowledged that design is a broad field with various design protocols followed in science disciplines. They recognized that through design, there could be a connection between art and science.

On the other hand, art and design students and lecturers acknowledged that art and design under STEAM can provide an opportunity to explore concepts and theories in a more engaging way, merging life learning skills with comprehension of principles and practice. Respondents noted that the arts enable inspiration and novelty as well as the development of cognitive and social growth. Lecturers who participated in the study further stated that art-based pedagogy focuses on process-oriented and reflective experiences and draws on a broad range of applied theatrical strategies.

These strategies can develop learners' creativity, abilities, and aesthetic awareness. They argued that the adoption of 'Art' under STEAM could significantly improve productivity and knowledge cross-pollination.

Students in the art and design discipline noted that by deeply engaging in the art and design curriculum, they acquire more practical skills, develop stronger attention to detail, and enhance their hand-eye coordination. Some lecturers view STEAM as an opportunity to share knowledge. They suggested that introducing art projects into a science class could help students better understand scientific concepts. By creating drawings, students can visualize what would normally be a very complex subject. Additionally, lecturers asserted that art and design education enable students to think outside the box, positively impacting their ability to solve complex scientific or mathematical problems, which is a core aspect of the STEAM education model. Lastly, lecturers specified that creative thinking skills precipitate innovation and allow students the freedom to explore different paths to a solution.

Respondents from art and design noted that through design, art could significantly contribute to providing creative and qualitative design thinking processes to the STEAM platform.

Discussion

Using a qualitative narrative analysis method, the study focused on interpreting respondents lived experiences in for of their narratives about Art as a discipline and 'Art' as a vital component under STEAM education model. Through inductive approach the study focused on focusing on the meaning of the participants, and describing a process using both expressive and persuasive language (Creswell, 2005). Study findings were analyzed to understand the respondents' lived experiences about art as a discipline and its inclusion in STEAM education model in their learning process and classroom space in both the art and design and science academic disciplines.

Differing narratives open up different worlds (Goodman, 1978). Basing on study findings the narratives from the science academic Siros highlighted a crucial finding that during application of STEAM learning model in their learning process they develop a particular disregard for the 'Art' component. On the issue of Art channeled through design under STEAM learning model it was noted that this approach could enable the connection of dots between art and science disciplines. Yet in Art and design discipline, STEAM seen as an opportunity to share knowledge, explore creative processes from art and design discipline and that through design aesthetic and design principles, design thinking process could be explored to enhance creativity and critical practical thinking skills.

The findings highlighted a fact the STEAM learning model is interpreted differently basing on our academic background. Yet STEAM education model was designed to fosters collaboration in classroom environment across academic disciplines to enhance creativity and learner centered approaches.

Today, active learning strategies are at fore front of pedagogical methodologies supplementing or replacing teachers. Within the realms of active learning, student-centered learning approaches have been adopted by institutions of learning due to their attributes that nature students as active participants in the learning processes. Conscious approach to STEAM learning model could go a long way to improve teaching and learning processes, which processes are immersed with ESD attributes of interactive, learner-centred, collaboration, inter and trans-disciplinarily, student centered learning enriches the key sustainability competencies in learning processes.

The aspect of collaboration and inter or trans-disciplinarily have been popularized by higher institutions of learning in Uganda to foster sustainable learning. However, their practicability internally within institutions have not been linked between departments, faculties and colleges. Cross cutting courses within faculties and university wide courses have been developed, but their impact on ground has remained a lip-service. The connecting dots between disciplines during teaching and learning are stuck in individual traditional academic feed storages (subjects) discrete to departments, faculties and schools.

Collaboration, Inter or trans-disciplinarity is only applied through research grant projects rather than during teaching and learning processes. This approach of using grants as a conduit for collaboration and inter - disciplinarily has created disconnect in teaching and learning processes. Impacting the way how instructors should employ inter disciplinary methodologies so as to make sustainable changes in their teaching strategies towards encouraging students' growth in various skill areas.

Perhaps most importantly, this state of affair raises pertinent questions about the quality of education in higher institutions of learning (Schleicher, 2020). Yet historically, education was considered as a social phenomenon serving the needs of society and providing sustainable knowledge to learners for survivability in the competitive environment. To improve on approaches to learning, various learning models have been developed geared towards enhancing learner-centered, collaboration and productivity, among them is the model which integrates Science Technology Engineering Art and Mathematics (STEAM).

Being a recent phenomenon in Uganda, STEAM education model has not been seamlessly integrated in instructional design approaches by higher institutions of learning in Uganda. Yet this model contains ESD principles of innovation-based education through deeper engagement of learners, to better understand content with innovative skills which all institutions of learning advocate for. STEAM facilitates a learning process that integrates Science, Technology, Engineering, the Arts and Mathematics as conduit for guiding and enhancing inquiry, dialogue, creativity, critical thinking and problem-solving skills.

The integration of 'Art' in STEM model was purposively conceived to nature a systematic revelation of creative capabilities engrained in art categories towards production of results which

are original and value, weaved through a creative process. Art enhances the foundation on which instructors can draw from to provide a well cross pollinated and lubricated instructional processes that fosters sustainable development through teaching and learning.

Even though STEAM education model has been somehow embraced by some science and no-science related courses within higher institutions of learning in Uganda, the 'Art' in STEAM model is not given due attention as a crucial element that adds value to creation input and outcome. The 'Art' has become a contentious element in regard to STEAM, some scholars questioning its importance in the instructional collaboration mix, and its applicability in teaching and learning processes within Ugandan context. The resultant effect of not embracing 'Art' in STEAM activity system, have yielded to un-coordinated approaches to application of creative processes within the activity system.

It is central to note that, Art lubricates creativity (Trilling & Fadel, 2009). In that, through creativity, creative skills are acquired which is a prerequisite for many academic disciplines today. If there is dearth knowledge about creative approaches in instruction methods, could hinder the learner's capabilities from developing their creative skills in a learning environment. The 'Art' under STEAM avails the creative artistic attributes to aid in solving a problem. Provides space for learners to connect dots towards integration of the acquired knowledge, skills, and abilities across disciplines.

The National Art Education Association (NAEA) noted that 'Art' under STEAM, infuses art and design principles, concepts, and techniques into STEM instruction processes. NAEA, according to Goldberg (2011) is closely linked with the arts-integration approaches which denote the use of the arts in teaching of other subjects. Arts integration is an approach to teaching under where learners construct and demonstrate understanding of subject matter through art forms (Silverstein and Layne, 2010). Art is further appreciated to associate with communication of information, shape our everyday lives, make a social statement and enjoyed for aesthetic beauty.

Art-integration practices are diverse, and can be interpreted in numerous ways due to their overlapping values and perceptions that traverse various disciplines, which makes it difficult to determine the limits of an art-integrated approach to STEAM education. This diversity is in harmony with situated learning that is contextualized, meaning that information becomes

meaningful if only presented in relation to its' context (Bredo, 1994; Clancey, 1992; Hung, 2002). Situated learning is a social process under where knowledge is co-constructed in a specific context and embedded within a particular social and physical environment (Lave and Wenger, 1991).

The use of art strategies to integrate art in other subjects (Marshall, 2014), brightens the importance of 'Art' under STEAM model. In that, art integration in transdisciplinary space demands for use of collaborative teaching methods as a means of acquiring knowledge. This is because knowledge is created out of interaction that takes place between learners with each other or with the environment (Krishner & Whitson, 1997).

Much as, arts-integration practices are diverse, this scholarly discussion focuses on 'Art' which is visually wrapped with art and design principles, concepts and techniques (visual art). Further, to deepen the understanding and importance of 'Art' in guiding learners' inquiry, dialogue creativity, critical thinking and problem-solving capabilities, this study explores design under visual arts to illuminate the artistic creative processes sometimes known as "the creeds of 'Art'. Purposively to show how the artistic sense is mixed with esthetics and novelty to stimulates creativity, feelings, queries and innovation across academic disciplines.

Design through the lens of visual arts is discussed in this study, to amplify the 'Art' in STEAM education approach so as to understand what type of 'Art' seamlessly interface with science, technology, engineering and mathematics. Within this framework, the concern of design is about the realization of a particular outcome rather than the science which is intended to establish the general laws (March, 1976). Through Art, design provides space to expose the creative design processes as an ideal fit in STEAM education activity system.

Design is a utilitarian human activity involving use of conscious effort to attain a state of affairs in which certain characteristics are evident (Coyne, R. D., Rosenman, M. A., & Radford, A. D.,1990). In the spirit of the study, it is a form of imagination that works with particular tools to simplify a workflow. Consequently, design activities are reviewed as the thinking activities executed by cognitive operations (Chan, 2015). A social construction creative process mediated by various aspects (Sserunjogi, 2017). Aspects which facilitate development of a plan for

arranging elements in a creative way to accomplish a particular purpose within an activity system (Engeström, 1987).

This creative framework for design activities, originates from conventionally known creative processes that blend different concepts together in a novel way by adopting, adding or combining them possesses a constructive thinking, what we term as "constructivism" (Tschang & Szczypula, 2006), achieved through integrated learning processes.

The 'Art' under STEAM, is acknowledged by Art educators as a space for advancing design education (Bequette & Bequette, 2012; Watson, 2015). Learners acquire design thinking skills for application in other subjects (Maeda's, 2013), towards enabling learners become innovators through various design activities, thus enhancing ESD principles (Tejedor, Segalàs, Barrón, Fernández-Morilla, Fuertes, Ruiz-Morales, & Hernández, 2019).

Today, vehicles are not only purchased for their engine power output but also for their aesthetic beauty - the feel and look, making aesthetic an important component in choice preference for many products. The enlightenment about aesthetics demonstrates that, through visual Art, design introduces aesthetics drape and design models into STEAM activity system. Design approaches enriches the teaching and learning processes, enabling learners acquire a bird eye view of solving problems. This creative process engages learners in finding or making connections and experimentation as opposed to following rigid, step-by-step rules.

To educate is to foster development of independent judgement and adoption of values (Johnson, 2007). Exploring design education through the 'Art' under STEAM model, introduces design methods and pedagogies that lay a foundation for development of problem-solving skills, innovation, critical thinking, social skills for empathy, collaboration and facilitation. Design education methods are developed with a focus on curiosity, problem framing and re-framing, developing and asking the right questions (Johnson, 2007). Further, provides hands on, place based project learning where learns from direct connections and interactions with the world (Keane & Keane, 2010). Organized through problem-based learning approaches, that are embedded in projects (Frascara, 2017).

Design education enhances personal knowledge acquired through design fundamentals based on the purpose, planning, efficiency, accountability, order, knowledge of people as design users, as well as sensitivity to content, context and sub-cultures (Johnson, 2007). Cross Nigel (2011) further explains that design is a 'multifaceted cognitive skill' and a natural intelligence 'design intelligence' which involves a deep reflective interaction on problems, solutions, the capacity of flexibility and the ability to switch between thinking and doing. This process augments creative skills for re-organizing problems so that they can be interpreted differently through re-framing process to create patterns which suggest possible solutions (ibid).

The 'Art' under STEAM explored through design instruction approaches avails space for learners and instructors to unearth rich solutions from problems which are open, complex, dynamic and networked. The emergency of STEAM model exposes the reality about the present-day problems which cannot be solved using the traditional problem-solving methodologies. This is further emphasized by Dorst (2015) that, new problems need radically different responses.

STEAM education model is enhanced with creative capabilities that nature, critical thinking-skills intended to seek and select necessary information to organize and test ideas. Supports materializing of ideas as a mode of creating change. Enables the construction of ideas that demands for social engagement, resulting into a purposeful action which forms the basis for human achievement, attributes which are found in all subject disciplines.

The 'Art' in STEAM unloads the creative capabilities that facilitates the relationships between the physical and social environment. The 'Art' also provide the physical part of the design which is fundamental in ideation processes, and ideal in enhancing 'Materiality' based on 'doing and making'. Integration of design instruction processes in learning processes; the knowledge of production technologies, research methods, how to see and evaluate products and systems, how to identify problems and opportunities for design interventions is cultivated and harvested.

A perfect fusion of Art with STEM can be traced to Leonardo Da Vinci -The "Renaissance Man" who seamlessly threaded art with science, mathematics and technology (Atalay & Chunn, 2005). In his creative endeavors Da Vinci, noted that, to develop a complete mind: Study the science of art; Study the art of science. Learn how to see. Realize that everything connects to everything

else (Pasipoularides, 2019). Da Vinci assertion connotes that; there is a symbiotic relationship between the Art and STEM. Second, Art is a crucial component in any creative activity system, it lays the foundation for nurturing of problem-solving skills, collaboration and inter-disciplinarity.

Da Vinci's proposal for development of a complete mind, advocates for a 'dialogic' approach. This approach which is evident in art and design education, enables creation of organic linkages, in problem solving processes. This organic approach is further emphasized by Cornett, (2015); Carabine, (2013) and Cunningham, (2009) that, a combination of Arts and STEM areas, promotes organic integration of the subjects, to enhance interdisciplinary approaches to teaching and learning processes. Leading to improved students' problem-solving and creativity skills (Boix Mansilla, Miller, Gardner, 2000).

Much as STEAM education approach is advocated for, it important to note that, the prescribed breadth of knowledge from each academic silo especially, science, technology, engineering, and mathematics have to be tailored for better comprehension of learning and application in non-science disciplines. The approach should be seamlessly woven to encourage meaningful communication and collaboration to enhance inter and trans-disciplinarity.

The Art under STEAM education model, in this scholarship is reviewed through the lens of visual art. Under the realms of visual art, design approaches are discussed to buttress art as an essential ingredient in STEAM education model. Design provides spaces for exploration of design thinking frameworks which are filled with competencies that enhance the learner's design thinking skills. The integration of design thinking frameworks such as ADDIE model, AC4D model, IDEO model, or Google Design Sprints, Hasso Plattner Institute of Design, Austin Center for Design, DEEP Design Thinking, Design Council UK, *Charity for Strategic Design,* Design for America into STEAM, not only provides considerable potentials that scaffolds the nurturing of student skills in problem solving and creativity across disciplines (Anderson, Adam, Taylor, Madden, Melles, Kuek, & Ewens, 2014), but also enhances collaboration, inter-disciplinarity and integration of Art in STEAM instructional activity system.

Discussion

Using a qualitative narrative analysis method, this study focused on interpreting respondents' lived experiences through their narratives about art as a discipline and its significance within the STEAM education model. Employing an inductive approach, the study emphasized understanding participants' meanings and describing processes with expressive and persuasive language (Creswell, 2005). The findings were analysed to understand respondents' experiences with art as a discipline and its integration into STEAM education within their learning processes and classroom environments across both art and design and science disciplines.

Differing narratives open up different worlds (Goodman, 1978). Based on the study's findings, narratives from the science academic participants revealed a crucial insight: during the application of the STEAM learning model, they often developed a disregard for the 'Art' component. However, when art is channelled through design within the STEAM model, it was noted that this approach could bridge the gap between art and science disciplines. In contrast, within the art and design discipline, STEAM is viewed as an opportunity to share knowledge and explore creative processes, leveraging design aesthetics and principles to enhance creativity and critical thinking skills.

The findings highlighted that the STEAM learning model is interpreted differently based on academic backgrounds. Nonetheless, the STEAM education model is designed to foster collaboration across academic disciplines, enhancing creativity and learner-centered approaches. Today, active learning strategies are at the forefront of pedagogical methodologies, supplementing or replacing traditional teaching methods. Within active learning realms, student-centered approaches have been adopted due to their ability to engage students as active participants in the learning process.

A conscious approach to the STEAM learning model could significantly improve teaching and learning processes, which are enriched with ESD attributes like interactivity, collaboration, and interdisciplinarity. Student-centered learning enhances key sustainability competencies in learning processes.

Higher institutions of learning in Uganda have popularized collaboration and interdisciplinary approaches to foster sustainable learning. However, practical implementation within institutions often lacks coordination between departments, faculties, and colleges. While cross-disciplinary courses have been developed, their impact remains superficial. Teaching and learning processes are still confined to traditional academic silos, with collaboration typically occurring only through research grants rather than in regular teaching methods. This reliance on grants for collaboration creates a disconnect in teaching and learning, affecting instructors' ability to employ interdisciplinary methodologies effectively.

This situation raises questions about the quality of education in higher institutions (Schleicher, 2020). Historically, education served societal needs, providing sustainable knowledge for survival in a competitive environment. To improve learning approaches, models like STEAM have been developed to enhance learner-centered, collaborative, and productive education. However, the STEAM model has not been seamlessly integrated into instructional designs by higher institutions in Uganda, despite its potential to foster innovation through deeper learner engagement.

The integration of 'Art' in the STEM model aims to systematically reveal creative capabilities, enhancing instructional processes that foster sustainable development. Although some science and non-science courses have embraced STEAM, 'Art' often lacks due attention, leading to uncoordinated creative processes within the system. Art, however, is crucial for creativity (Trilling & Fadel, 2009), aiding problem-solving by connecting acquired knowledge, skills, and abilities across disciplines.

The National Art Education Association (NAEA) notes that 'Art' within STEAM infuses art and design principles into STEM instruction, aligning with arts-integration approaches that use art to teach other subjects (Goldberg, 2011; Silverstein & Layne, 2010). Art integration, being diverse and contextually meaningful (Bredo, 1994; Clancey, 1992; Hung, 2002), enhances teaching and learning by embedding knowledge within social and physical environments (Lave & Wenger, 1991). Art-integration practices are diverse and can be interpreted in various ways, making it challenging to define the limits of an art-integrated STEAM approach. This diversity aligns with situated learning, where knowledge is co-constructed in specific contexts (Lave & Wenger, 1991).

Using art strategies to integrate art into other subjects highlights the importance of 'Art' in the STEAM model. Art integration in a transdisciplinary space demands collaborative teaching methods, as knowledge is created through interactions between learners and their environment (Krishner & Whitson, 1997).

Art educators acknowledge 'Art' under STEAM as a space for advancing design education, where learners acquire design thinking skills applicable to other subjects (Bequette & Bequette, 2012; Watson, 2015; Maeda, 2013). This process aligns with ESD principles (Tejedor et al., 2019), integrating aesthetics into STEAM to enrich problem-solving capabilities. Art fosters independent judgment and values (Johnson, 2007), with design education promoting curiosity, problem framing, hands-on learning, and project-based learning (Keane & Keane, 2010; Frascara, 2017).

The 'Art' in STEAM provides a space for rich problem-solving, addressing complex, dynamic issues requiring new responses (Dorst, 2015). The STEAM model, enhanced with creative capabilities, nurtures critical thinking, materializes ideas, and supports social engagement, forming the basis for human achievement across disciplines.

This study focuses on 'Art' within visual art principles, concepts, and techniques. By exploring design within visual arts, the study aims to understand how art seamlessly interfaces with science, technology, engineering, and mathematics. Design, concerned with achieving particular outcomes, exposes creative processes that fit well within the STEAM system. Design activities involve conscious effort to achieve desired results, making it a form of imaginative and constructive thinking (Coyne, Rosenman, & Radford, 1990).

Design education enhances personal knowledge through design fundamentals, considering purpose, planning, efficiency, accountability, and context (Johnson, 2007). Cross Nigel (2011) describes design as a multifaceted cognitive skill involving reflective interaction on problems and solutions. This process encourages re-framing problems to create new patterns for solutions. Problems are best solved when approached in a comprehensive and systemic way. The goal of this problem-solving process is to guide and organize work to turn ideas into concrete solutions. This process is about envisioning and planning the creation of objects, interactive systems, among others, it is user-centered achieved through a design thinking approach

Design thinking is a human-centered, iterative methodology that designers use to solve problems. This mode of thinking is premised on three core principles empathy, expansive thinking, and experimentation, represented through various steps to guide the understanding of users, define their problems, create prototypes, and testing solutions termed as design thinking model.

A design thinking model is a framework that guides you through the different stages of design thinking. Various design thinking models such as ADDIE, AC4D, IDEO, and many more others have been developed as tools to structure the thinking process and navigate the complexity of problem space. Exploration and integration of design thinking frameworks through 'ART' under STEAM activity system could augment problem-solving and creativity across disciplines (Anderson et al., 2014).

The inclusion of design through ART in STEAM instruction cultivates knowledge of production technologies, research methods, and problem identification, enhancing learning processes. This fusion of Art with STEM, tracing back to Leonardo Da Vinci's holistic approach, advocates for a 'dialogic' method that promotes interdisciplinary integration, enhancing problem-solving and creativity (Pasipoularides, 2019).

Da Vinci's 'dialogic' approach, is vividly evident in art and design education, creating organic linkages in problem-solving (Cornett, 2015; Carabine, 2013; Cunningham, 2009). This approach promotes improved problem-solving and creativity skills (Boix Mansilla, Miller, Gardner, 2000).

The 'dialogic' approach harmonizes a perfect fusion of Art with STEM who integrates art with science, mathematics, and technology (Atalay & Chunn, 2005). Da Vinci's approach emphasizes the symbiotic relationship between art and STEM, highlighting art's role in problem-solving and interdisciplinary collaboration.

While STEAM model holds significant potential for enriching education, its successful integration requires a seamless blending of Art with STEM, fostering meaningful communication and collaboration. By focusing on design within visual arts, this study highlights the essential role of 'Art' in STEAM, promoting competencies that enhance creativity and problem-solving across academic disciplines.

CONCLUSION AND RECOMMENDATIONS

There is a significant lack of understanding among students and lecturers in science disciplines about the potential benefits of integrating 'Art' into STEAM. However, in today's rapidly changing world, creativity is a highly desired skill, essential to meet increasing social, emotional, and intellectual demands. This scholarly discussion explored the creative capabilities and importance of 'Art' within the STEAM education model through design. It provided a space to deeply understand how Art can be integrated into STEAM pedagogy and how it enhances creativity.

Inspired by Da Vinci's assertion that to develop a complete mind, one must study the science of art and the art of science, learn how to see, and realize that everything connects to everything else, this discussion advocates for a 'dialogic' approach. Such an approach enables the creation of organic linkages in problem-solving processes. The argument is supported for the inclusion and adoption of design thinking frameworks to solve problems and improve how learners explore the creative capabilities that art offers in problem-solving contexts.

This discussion ignites a conversation about what Art is and how it can contribute to the STEM activity system, aiming to generate a paradigm shift in how art is viewed by some academicians in science silos within institutions of higher learning in Uganda. lastly, it emphasizes the importance of appreciating Art as a discipline that supplements the instruction and learning process through the use of the STEAM activity system, enriching the principles of Education for Sustainable Development (ESD).

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