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Science and sociality: achieving the social dimensions of science through contextualization of secondary school classroom instruction

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Abstract

This position paper is predicated on two focus areas. First, it recognises that scientific inquiry is performed in social situations and questions whether and how standard epistemology can be augmented to tackle this aspect. Within this focus, the goals of science education are reviewed. The second focus addresses sociality as an essential feature of knowledge and questions how standard epistemology can be reformed from this generally social perspective. Specifically, this study on one hand addresses the social dimension of science education, and on the other hand, examines the suitability of instructional contextualisation as a possible strategy to achieve the social dimensions of science education. The aim is to initiate a conversation about the importance of framing science education studies and experiences within the sociocultural context of interests and needs to achieve reliable participation of all concerned. To this end, this paper argues that science education ought to place considerable emphasis on students' acquisition of values and skills of sociality. Furthermore, a comprehensive goal of science education should constitute both the normative and the non-normative aspects of science with a particular emphasis on the development of character formation, moral values, creativity skills and competences. There is, therefore, a need for an examination of the social dimensions of science education and its curriculum implications, especially as science education serves as the nexus between science and society.

Keywords: Science, sociality, contextualization, epistemology, scientific inquiry

Introduction

The impact of scientific inquiry on the life and social relations of people, as well as the influence of social relations and values on scientific research, and the social aspects of inquiry itself have been highlighted by studies on social dimensions of scientific knowledge (Longino, 2019). The rise of environmentalism, which is a social movement that is critical of the conventional science, is raising questions about what constitute the philosophy of science and science education in contemporary times. When we consider that a lot of complex scientific phenomena exist within societies, which include microplastics in oceans, biodiversity loss, over consumption and production, glacial melt in the Arctic, food insecurity, extreme hurricanes and floods, and climate-induced migration (Pahnke, O'Donnell & Bascopé, 2019), then a shift in the philosophy of science towards naturalism and pragmatism as a result of the apprehension of the social implications of modern technological activities and innovations becomes necessary. There are also epistemological concerns raised by modern scientific discoveries, and the anti-normative approaches in the sociology of science (Longino, 2019). Furthermore, the development and adoption of the Sustainable Development Goals (SDGs) by the United Nations (Lawrence, Ihebuzor & Lawrence, 2020) is a validation of the shift in the philosophy of science, and thus provide justification for this study which is a literal examination of the social dimensions of science as a philosophical analysis of the instructional objectives of science education. According to Zeidler (2014), this can only be achieved by recognising the humanistic perspective of science literacy in science education.

Science and Society: An Epistemological Characterisation of the Expectations of Science Education

Science has been at the forefront of the advancements made by society. Technological innovations have transformed the living standards of society. Studies report that advancements in science have transformed the standard and structures of human existence which has led to a significant increase on the importance of science education to provide skills and competence for the challenges of modern society (Stewart, 2005; Bentley, 2012; Fitria & Kenedi, 2021). The 21st century presents complex challenges, mainly non-linear, which requires a different approach compared to the science processes and procedures of the previous era (Nowotny, 2015). As a result, Miedema (2022) stated that for science to be effective, it must have a focused mission that is inclusive, and really multidisciplinary. This implies that science should target public and social needs, not just push for technological impact, but consider that technology cannot provide solutions to all human challenges as the society poorly understood.

Unfolding events show that technological advancement and the unregulated access to the internet have increased the chances of knowledge accumulation, both authentic and dangerous, with the potential to transform the social environment (Yun et al., 2017). Pardo and

Cotte (2018) posit that there is wide availability of both authentic and harmful information, which is not perfectly suited to every context. Therefore, expertise for authentication of scientific knowledge is essential to be applied to any particular context, in order to reduce the uncertainty therein (Yun et al., 2019). According to Romero-Rodríguez et al. (2020), these concerns have given rise to a number of concepts which include what is termed *Social Appropriation of Knowledge* (SAK), which is a demonstration of societal awareness on the need to delineate scientific processes and products. There are many definitions, explanations and applications of SAK in literature. However, the suggestion by Romero-Rodríguez et al. (2020) that SAK deals with the process of social structuring of the application of scientific knowledge to enhance the development of society aligns with the position of this paper. Studies have shown that there is increased interest in SAK by nations in South America who are generating methodological frameworks for its implementation. This interest in SAK can be attributed to its potential to generate uninterrupted processes of social learning, and to foster economic growth and competitiveness of countries (Quintero & Zamora, 2017). Similarly, the promotion of SAK provides a rational basis for social development of the environment, and at the same time benefits from the outcomes of scientific research, which is a result of the generation and application of the scientific knowledge to local context (Vaccarezza, 2015; Uribe-Tirado, Ochoa-Gutiérrez & Medina-Alfonso, 2019). This serves as one of the compelling and plausible examples of instilling certain degrees of normativity to the scientific enterprise.

The quest for sustenance of the environment (human ecosystem) led to research studies which culminated in the discovery of alternative energy sources. This highlights an essential component of education; that is, the social dimensions of knowledge creation and utilization, which is a core objective of education. Critical contemplation of the extraordinary environmental, health related and scientific problems confronting modern society have necessitated the need for focused science content rather than science coverage education reforms (Karisan & Zeidler, 2017), thus enhancing the possibilities of achieving the Sustainable Development Goals (SDGs). This, therefore, underscores the need for the evolution and acquisition of sound conceptual knowledge of Science, Technology, Engineering and Mathematics (STEM) by students through well focused science instruction (Fortus & Krajcik, 2020), with a view to stimulate knowledge and interest in environmental sustainability.

Studies conducted by Eurydice Network (2011) and National Research Council (2012) highlighted the significance of scientific education and the fundamental role of school science in providing learners with the requisite knowledge and skills to address socio-scientific issues that they will encounter. This is further corroborated by Organisation for Economic Co-operation and Development (OECD, 2013) which stated that policy documents of science education globally underlines the relevance of scientific literacy and suggest that if learners are to become scientifically literate, it is essential that they develop their understanding about the processes of science and the type of knowledge science produces, and develop the ability to apply this scientific knowledge in every day contexts. It is essentially significant for students to possess the ability to frame any science topic in a personal, thoughtful and meaningful context. This ability will require a contextual viewpoint of scientific literacy that entails, among other skills, the proclivity and ability to envision the role of sociocultural contexts within which topics reside (Zeidler, 2014). However, the case has been far from ideal as science education has over the years focused on students' achievement in subjects such as Chemistry, Mathematics, and Physics among others as shown by Zeidler (2014), and not on students' acquisition of values and skills of sociality.

Pierson, Clark and Kelly (2019) highlighted that there have been reported tension with regard to the focus of science education as researchers and practitioners have over time prioritized students' acquisition of, and involvement in, science practices over students' development of declarative knowledge about science concepts and processes. This is visible in the K-12 science standards such as the Next Generation Science Standards, with adjusted kinds of professional science practices, projecting what it described as *developmentally appropriate pathways* from novice to expert practice (Pierson, Clark & Kelly, 2019). Within this perspective, this paper highlights the position of Zeidler (2014) which asserts that science practice comprises of two essential components, namely: the *normative components* (which include prescription of courses of action, decisions about courses of action, and choices of products to be created) and the *non-normative components* (which include observation, data gathering, predictions, scientific methods and process). These components give meaning to the nature of science. However, more focus of science education is drawn towards the non-normative component of science (Zeidler, 2014). Science education presents science as if it exists independently of human affairs and interactions, and by so doing, alienates science and scientists from humanistic considerations in scientific practices.

Historically, science education has, as its primary role, the promotion of the comprehension of scientific facts, principles, and theories (Holbrook, 2010). This emphasis on the promotion of scientific facts and theories enhances the chance for the abdication of any feeling of responsibility during science practices, or in the decision making process about the daily use of science by ordinary citizens outside of research paradigms (Zeidler, 2014). This is further buttressed by the position of Harris (2010) who asserts that the consequences of separating facts and values are multiculturalism, political correctness, moral relativism and the tolerance of the intolerance. Hence, science became a tool for proving who is powerful, what is correct and not what is right. Facts cannot and should not be independent of values. As Harris (2010) rightly pointed out, "Einstein famously questioned the views of his equally renowned peer, Bohr, on quantum mechanics, and yet they are both physicists with same experimental findings and mathematical techniques; Einstein's critique then becomes a question which bothers on values and philosophies, and not about facts" (Harris, 2010: 179 – 180). Facts can sometimes be devoid of values.

Inspired by the need to unify the normative and non-normative aspects of science, the Board on Science Education (BOSE) at the National Academy of Science (NAS, 2012) developed what it described as the ‘‘core’’ philosophical standards for the new framework that define the fundamental scientific practices and concepts that students are expected to grasp by the end of their secondary school (K-12) education. As the ideas are developed, they should meet at least two of the following standards:

1. Hold extensive significance among multiple sciences or engineering disciplines or be the main coordinating principle of a sole discipline.
2. Provide an essential tool for the comprehension or examination of more complex concepts as well as solving problems.
3. Address the interests and life experiences of students or be related to societal or personal concerns that require scientific knowledge.
4. Be teachable and learnable over various levels at increasing degrees of depth and complexity. That is, a concept can be taught to students from their earliest stage in K-12 and would continue to learn the concept over the next stages of K-12 education but with broad scope to sustain continued investigation over years (NAS, 2012: p. 36).

An analysis of the overstated philosophical standards for secondary school (K-12) science education shows that consideration was given to the implication of science literacy on students' daily life experiences. The third standard alluded to the potential to utilise students' personal epistemologies as foundation for learning (Zeidler, 2014). To achieve this will require a well-defined approach to instruction, which this paper intends to address.

Science education plays two vital roles in society (Tytler & Osborne, 2017). On one hand, it is charged with educating the next generation of society in and about science, an education that essentially requires development of an understanding of, and appreciation of the explanatory hypotheses and set of scientific skills that science offers the material world. Secondly, it has the responsibility to educate and equip the next generation of scientists, as well as enhance the professional development and training of science teachers for the basic and higher secondary (High school) levels of education (Tytler & Osborne, 2017; National Science Teachers Association, NSTA - 2023). These roles identified solely with the non-normative aspect of science by addressing the acquisition of scientific skills without consideration for how, where and when these skills are necessary, the modes of utilisation and the implications of such skills to the society. Bringing a sense of equity between the normative and non-normative aspects, studies by Karisan and Zeidler (2017) and Roche et al (2020) highlighted that a major goal of science education is the development of functionally and scientifically well-educated learners who can make responsible contributions to the society. This corroborates the position of Karisan and Zeidler (2017) and Härtig et al. (2020) which stated that the major goal of science education is the development of learners who would be functionally and scientifically literate. Scientific literacy should ultimately impact an individual's worldview (Lederman et al., 2013). Worldviews are shaped by experiences and can be reshaped through education. Therefore, science education has a significant role to play in developing a humanistic worldview for scientists.

Critical Review of the Goals of Science Education in the 21st Century

The debate on what constitute the goals of science education has been an enduring issue. This debate has been constantly explored within the realm of the meaning and purpose of scientific literacy (American Association for the Advancement of Science, 1993; National Research Council, 1996; Saddler, 2011; Lederman, Lederman & Antink, 2013). What does scientific literacy entail for individuals' daily lives (Zeidler, 2014)? These questions are necessary not only within the formal and informal context, but in the context of the influence of science literacy on the life-long development of individuals and society. According to Zeidler (2014), to address this question would require the blurring of the sharp edges of disciplinary and cultural borderlines; that is, removing the boundaries separating the normative and non-normative aspects of science and science education. This, therefore, authenticates the position of Virginia Mathematics and Science Coalition (2013) which asserts that scientific literacy involves the ability to make informed decisions on socio-scientific issues. According to

Lederman, Lederman and Antink (2013), the most important aspect of scientific literacy is that which impacts students' decisions about individual and societal challenges.

Studies conducted by Olson (2018), Murphy, Smith and Broderick (2019), McComas and Clough (2020), and Nouri et al. (2021) argued that the major goal of science education is the facilitation of students' understanding of how and why science works as well as the comprehension of the nature of science (NOS). Numerous studies have highlighted the advantages of teaching NOS (Murphy et al., 2019). Some of the studies suggest that knowledge of NOS empowers learners to understand the tentative and developmental processes of science as a human activity, which makes it more interesting to learners (Abd-El-Khalick, 2012). Other studies suggest that learners who graduate with sophisticated ideas of NOS possess better grasp of scientific knowledge and the processes involved in its production, as well as an advanced comprehension of *socio-scientific* issues (Khishfe 2012; Lederman et al. 2013). However, there is a raging debate about the exact form of NOS knowledge learners should acquire (Murphy et al., 2019).

Over the past decades, studies on NOS have concentrated on what Kampourakis (2016) describes as 'general aspects' conceptualisation of NOS, which is a conceptualisation that is built on a list of overall aspects of science as agreed by science educators. There have been criticisms of 'general aspects' conceptualisation of NOS in recent years as it is perceived to be too narrow and does not take into account the multifaceted nature of the different scientific disciplines (Erduran & Dagher, 2014a; Irzik &d Nola, 2014). Meanwhile, advocates of the 'general aspects' conceptualisation of NOS such as Lederman and Lederman (2014) and Kampourakis (2016) argue that it is a basic foundation for the development of learners' conception of NOS and for addressing the misconceptions of NOS that learners bring to school. They further argue that these misconceptions, if not addressed during the foundational part of learners' experience of science, would undermine the relevance of scientific literacy. Murphy et al. (2019) stated that 'general aspects' conceptualisation of science should be taught at the foundational stage and as the students advance in their studies, they should be introduced to disciplinary base NOS topics. The 'general aspects' conceptualisation of NOS, however, is not the focus of this paper. Instead, this position paper primarily focuses on the role of science education in achieving sociality among science students and future scientists.

A study conducted by Pierson, Clark and Kelly (2019) noted that there is increasing tension as science education researchers and practitioners have placed emphasis on students' development of, and involvement in, science practices over students' acquisition of mere expressive knowledge of science concepts and processes. These practices require thorough contemplation of how students can be placed in social contexts to aid the capture and transformation of scientific knowledge and activities (Engle & Conant, 2010). One of the most important goals of science education is the attainment of critical and/or higher-order thinking skills which enables the learner to contribute meaningfully to the development and sustenance of society (Cullinane, 2015). The process involved in classroom development, transmission and acquisition of these skills and values is referred to as instruction. According to Şimşek (2011), instruction requires more than systematic guidance for learning. It requires a purposeful organization of experiences to assist students to achieve the desired improvement in their performances and the learning objectives.

Studies conducted by Zeidler and Sadler (2008) and Choi et al. (2011) emphasised the need for science educators to pay meticulous attention to normative characteristics such as character cultivation, and the growth in morality and virtue of students as essential components of science education, above and beyond simply acquiring scientific knowledge or reasoning ability. Hence, a comprehensive goal of science education should constitute both the normative and the non-normative aspects of science with a particular emphasis on the development of character formation, moral values, creativity skills and competences.

Social Dimensions of Science Education – Curriculum Implications for Secondary School Science

Science, just like every human activity, is in part socially constructed, and so is prone to the influences of both the noble and less-noble social constructs. That is, scientists have cultural and social inclinations, and these inclinations, other than the pure love for truth and knowledge can drive their efforts (Fernández, Benitez & Romero-Maltrana, 2022). As highlighted by Rhodes (2012), the huge investment in fundamental physics which was generated by the world wars, the Manhattan project being a famous case in point, is a good example of the influence of society on scientific products. This shows that science is, after all, a social enterprise influenced by its social character and cultural connectivity. There is, therefore, the need for an examination of the social dimensions of science education and its curriculum implications; especially as science education serves as the nexus between science and the society.

Studies on social dimensions of education have varied over time. As highlighted in National Research Council (2002), it has evolved from the works of Dewey (1916) on bridging the culture/educational gap between the races, to the eradication of segregation, the call for the avoidance of deficit model, stereotype threats, among others. The emphasis of this paper is the socio-cultural and socio-economic significance of science and science education, with a particular focus on the epistemological situation of scientific objectives and the nexus with sociality. Various studies have highlighted scientific literacy as a major goal of science education. There are equally suggestions that creating platforms for the refinement of character and conceptualisation of the role of the nature of science (NOS) are consistent with progressive views of science education and scientific literacy (Sadler & Zeidler, 2009; Zeidler & Sadler, 2010). Furthermore, classroom research has demonstrated that a fully enacted SSI approach to science education becomes a transformative process for participating students and their teacher.

Science is taught in senior secondary (K-12) schools as Biology, Chemistry and physics (Tupas & Palmares, 2018; Zulhafizh, 2021). The objectives of senior secondary school (K-12) science instruction is to produce students who are creative and critical solution providers, responsible nature agents, innovative thinkers, and effective communicators (Montebon, 2014). The position of Montebon (2014) corroborates the objectives of senior secondary school science teaching and learning released by the Nigerian Education Research and Development Council (NERDC, 2008). The document emphasizes among others, the provision and acquisition of creative thinking skills and attitude, which will enable students to contribute meaningfully to the societal development. These objectives highlight the social enterprise of science education.

The standards for secondary school (K–12) science instruction comprise of adjusted kinds of professional practices of science with the intention to present developmentally suitable pathways from novice to expert practices (Next Generation Science Standards, 2013). Significant engagement in science activities, therefore, necessitates that students be positioned as knowledge agents. Hence, instead of just learning about science process skills, students should acquire tools and processes of science to enhance their knowledge of how the world works (VanLehn 2013; Berland et al. 2016). These tools, processes and skills are vital elements for the development and sustainability of the society, and thus allude to the importance of incorporating sustainability education to the objectives of secondary school science instruction. There is growing consensus that sustainability education as enshrined in the Sustainable Development Goals of the United Nations (UN) plays critical roles in the sustainability and development of any nation (United Nations Education, Scientific and Cultural Organisation, 2016). This is because sustainability education facilitates reflective learning, knowledge, skills and greater agency to address complex sustainability challenges. This consensus also underscores the need to examine the interactive influence of science education in the development of society.

At every point in the history of society, the social dimensions of education are determined by the values, ideals and aspirations of society. Sorenson (2018) enunciated that the social dimension of education runs beyond development of interpersonal relationship and social skills which will support learners throughout their lives. Education emphasizes the importance of the social system; it supports citizens' collective ideals and goals. On the one hand, education advocates consensus in social thought and cooperation. On the other hand, education encourages people to examine the places where a society may need improvement. When arguing on the determinants of education in any society, Popova-Koskarova (2011) suggested that growth and the status of members of any society affect society in a special way. Hence, the purpose of education is determined by the integrative world processes of globalization. The system of values also has great influence on education as a result of the awareness of the search for new values and the minimization of the old ones. According to Sarah, Prasetyo and Wilujeng (2018), the school is one of the effective systems that foster the values of life in students, which should be done by all stakeholders in the school.

The social dimensions of science education are overviews of the critical roles of science education in enhancing the scientific development of society, and the means of achieving these developmental roles. Hence, the social dimensions in learning of sciences must emphasize the objectives that society set out to achieve through teaching and learning of science subjects. For example, the International Union of Pure and Applied Physics (IUPAP) asserts that the importance of physics include the following: provision of inspiration for young people to expand the boundaries of knowledge about nature; generation of fundamental knowledge needed for future technological advances that will drive the economic engines of society; provision of trained personnel and technological infrastructure to take charge of the scientific discoveries and innovations; an extension and understanding of other disciplines; provision of basic understanding needed for the development of new instruments, tools and applications (IUPAP, 1999). These objectives address the basic contributions expected of physics and physics graduates to society. Studies conducted by Van Lehn (2013) and Berland et al. (2016) suggest that active engagement in science practices necessitates that learners be trained as epistemic agents, which implies that instead of acquiring knowledge about science, learners should acquire disciplinary tools and processes to discover significant elements of the world.

Children are usually asked the following questions: “What do you want to become when you grow up?” Most of the times, they roll out such responses as: doctor, engineer, pilot, and geologist, among others. However, these career choices are mostly products of their perception of the values placed on these professions by society. The likelihood that a child who hopes to become a Doctor or Engineer or Pilot or Geologist will understand the specific roles society expects of these professions is very slim, and will depend on the exposure the child receives especially in the classroom. As stated in the objectives published by NERDC (2008), students can achieve these dreams through the acquisition of basic concepts and principles of basic science as a preparation for future studies. In the light of the questions, aspirations and desires, the social dimensions of science education and learning should provide students the platform to acquire through participatory and practical classroom activities, the social and networking skills needed to be a functional member of the 21st century society. Therefore, the social dimensions of science education should emphasize the following:

1. Acquisition and retention of intra-personal and inter-personal relationship skills.
2. Acceptance and promotion of individuals’ rights.
3. Acquisition of teamwork etiquette as well as the recognition of diversity of ideas, skills, strengths and individuals’ background.
4. Respect for the nature of the environment and promotion of environmental sustainability.
5. Improvement in the living standard of society through the maintenance of positive behaviour.
6. Acquisition of innovative skills to enable students to make advancements in the basic structures of society.

These skills and competencies are highlighted in the Sustainable Development Goals (SDGs) of the United Nations. However, to be able to design a teaching-learning environment that reinforces students’ development of disciplinary knowledge and practices, experts have suggested learning progressions for science activities (Pierson, Clark & Kelly, 2019). Learning progressions symbolise an all-inclusive summary of the stages in the curriculum, which are infrequently reproduced in the context-dependent and unparalleled academic trajectory of students (Svoboda & Passmore, 2013). Studies have shown that there is usually a shift in the experiences and practical skills that students identify as relevant as a result of their engagements and interactions with the classroom environment, teachers and peers (Louca et al. 2004; Berland et al., 2016). Studies have also shown that learning progressions for complex science exercises do not signify fixed direct pathways for students (Pierson et al., 2017). Hence, there are questions about the usefulness of learning progressions for activity-based science teaching and learning (Hammer & Sikorski, 2015).

Instructional Approach to Social Dimensions of Science Education

Contemporary academics explore both formal and informal inquiry approaches in tackling the social characteristics of knowledge. Those who put more emphasis on the formal approaches have greater inclination towards empirical study of the effects of community formations on the quality and dissemination of knowledge, and pay less attention to questions about rationality, objectivity, or justification. Those interested in the informal models are more inclined towards understanding the position of the community in improving desired elements of inquiry such as rationality and objectivity, and also in the rationalization of the means of knowledge generation (Longino, 2019). Depending on teachers' approaches to classroom instruction, there are implications on the achievement of the objectives of science education, especially the now-determined-important objective of learning that is the social dimension of education.

The instructional implications of the social dimensions of science education would seek to find answers to questions such as: what is the best way to convey science content and process skills so that students can retain, remember and apply them in their daily encounters? How can a teacher communicate effectively with students who wonder about the reasons, meaning and relevance of the concepts they study in science subjects? How can students be enabled to acquire science concepts and techniques for functional application in real world situations? These are some of the challenges that teachers face in science instructional activities. A variety of approaches have been utilised in the promotion of more informed conceptions of the Nature of Science (NOS). These approaches can be grouped into implicit/explicit or contextualized/non-contextualized. The implicit (contextual) approach is predicated on the fact that the development of a more informed depiction of NOS is a natural outcome of the learners' active involvement in various activities, whereas the explicit (non-contextual) approach assumes that this development should be deliberately achieved through proper planning of moments that promote reflections about science (Abd-El-Khalick & Akerson, 2009). Non-contextualized approach utilises the first aspect of teaching which involves the use of discussion activities that are not directly related to scientific concepts. In contrast, contextualized approach integrates NOS into specific scientific content or processes (Clough, 2006). It is expected that contextually focused instructional strategy will enhance a proper evolution of the social dimensions of learning since both concepts (context and social) are two sides of the same coin. Researchers, teachers, and education stakeholders have accepted instructional contextualisation as a constructivist technique and an inquiry-based instructional exercise that links the gap between concepts and real-life experiences (Rivet & Krajcik, 2008). Studies conducted by King and Ritchie (2012) and Giamellaro (2014) emphasised that insights gained from studies on instructional approaches to science education have provided proof that instructional contextualisation enables students' insights and increases their interest in science education.

- ***Classroom Implementation*: *The Contextualized Learning Model***

Contextually responsive instruction can be identified as a promising strategy that engages students actively and promote improved opportunity for knowledge and skills acquisition. This instructional model is a conception of teaching and learning activities that enables teachers to relate subject matter content to real world applications while emphasising the teaching of basic skills in the context of disciplinary topic areas. Pate (2003) concludes that contextual instruction enables learning in which students employ their academic understandings and abilities in a variety of in and out-of-school contexts to solve simulated or real world problems, both alone and with others. This means that the process of learning and instruction in the classroom must be connected to the real world. This can be done by using various teaching techniques such as simulation, group work, question and answer session, and games. Contextual learning theory states that learning occurs only when learners process new information or knowledge in such a way that it makes sense to them in their own frames or reference (Texas Collaborative for Teaching Excellence, 2007). This means that for learning to occur, there must be a connection between what is to be learnt by the learner and the knowledge the learner brings into the classroom. There must be a connection between learning and the learner's inner worlds of memory, experience and response. This approach to instruction assumes that the mind of the learner naturally seeks meaning in context, that is, in relation to the learner's current environment.

Mazzeo (2008) provided more insight into Contextualized Teaching and Learning (CTL) by describing it as a diverse family of instructional strategies designed to more seamlessly link the learning of foundational skills and academic or occupational content by focusing teaching and learning squarely on concrete applications in a specific context that is of interest to the student. According to Suryawati and Osman (2018), contextual approach is the cornerstone philosophy of constructivism, namely, learning philosophy that emphasizes learning is not just about memorizing. Studies conducted by Ardan et al. (2015) suggested that learning at school would more possibly provide a clear and relevant picture if the learning theme is unearthed from local potentials. Considerable research indicates that local potentials could be integrated into learning at school in order to equip the learners with the requisite knowledge to understand the values within their surrounding and hence contribute meaningfully to the sustenance and development of their environment. Picardal and Sanchez (2022) stated that contextualised instruction has improved classroom science instructional activities and scientific performance, but has minimal effects on future science learning. However, Fortus and Krajcik (2020) cautions that appropriate measures must be taken in the design of contextualised learning environments to escape unsuitable contextualisation, which is capable of creating confusion and trigger irrelevant knowledge.

A study conducted by Sanchez et al. (2018) corroborated by Gecolea and Amon (2022) on the utilisation of a technique grounded on the seven principles of contextualisation provided opportunities for Indigenous Mexican youths to acquire knowledge of science in a way that aligned with their own cultural values. The seven principles of contextualisation precisely originate from social perception, socialisation, and social narratives of the students, thus enhancing students' ability to explore the disparities between their informal life experiences and the experiences of formal school setting while acquiring knowledge of complex science concepts. The technique adopted by the study was scientifically authenticated and incorporated products of the environment and socialisation, thereby identifying with the principles of Culturally Relevant Pedagogy and Indigenous Education. These guidelines facilitated an improvement in the social relevance of a middle school science curriculum on natural selection for students (Gecolea & Amon, 2022).

This study views Pate's (2003) principles of contextual learning as a viable model for achieving social dimensions of learning. Pate (2003) proposed framework principles of contextual learning as follows;

i. Students are actively engaged.

ii. Students view learning as relevant.

iii. Students assist each other to learn through cooperation, discourse, teamwork, and self-reflection.

iv. Students are encouraged to take responsibility for the monitoring and development of their own learning.

v. Students are inspired to become active participants in the improvement of society.

vi. Student learning is assessed in multiple ways.

vii. Students' perspectives and opinions are valued and respected.

viii. Teacher acts as facilitator of student learning.

ix. Teacher employs a variety of appropriate teaching techniques.

x. The learning environment is dynamic and exciting.

xi. Higher order thinking and problem solving are emphasized.

xii. The process of learning is as important as the context that is learned.

xiii. Appreciating students' diverse life contexts and prior experiences are fundamental to learning.

xiv. Knowledge is interdisciplinary and extends beyond the boundaries of conventional classrooms.

Furthermore, the idea of S*ocioscientific Issues* (SSI) base instruction, especially when we consider the humanistic features that constitute this kind of instruction, becomes a platform for the cultivation of character and values as global citizens that the idea of social dimensions seeks to achieve (Lee at al., 2013). There have been arguments and initial evidence by studies conducted by researchers such as Sadler (2004), Fowler, Zeidler and Sadler (2009) and Mueller and Zeidler (2010) that the SSI instruction can be an effective method for the facilitation of character and values growth within students. SSI requires what Zeidler and Keefer (2006, p. 8) described as "the consideration of ethical issues and construction of moral judgments about scientific topics via social interaction and discourse". Thus, a social setting is formulated where students engage in moral reasoning and perform moral actions. This position is supported by Mueller and Zeidler (2010) who stressed the fundamental importance of the ethical decisions for students who are participating more fully in actions that affect our communities and our larger ecological habitat.

- ***The Assessment Pattern – An Evaluation of the Domains of Learning Objectives***

The performance of students at any prescribed examination is used as a criterion for determining the level of implementation of learning objectives and the level of learning that have taken place. Therefore, students' learning outcomes serves multiple roles. According to Lesch (1995), learning outcomes are statements that describe significant and essential level of knowledge acquisition that learners have achieved, and can reliably demonstrate at the end of a course or program. In other words, learning outcomes identify the level of implementation of the learning objective at the end of a course or program.

The measurement of learning outcomes has for long been carried out mostly through *paper* and *pencil* assessment, especially in developing countries. As revealed by Chandio, Pandhiani and Iqbal (2016), public sector examination system employs the forms of assessment which do not transcend beyond the lower degrees of learning. This type of assessment examines the cognitive domain of educational objectives (Harvey, 2019), which does not foster holistic development of the learner. According to Eshun and Mansah (2013), one critical shortcoming in the system of assessment and evaluation, which is now being reformed, is that the measurement of student achievement was directed mainly towards the measurement of cognitive behaviours such as knowledge, understanding and other thinking skills which are usually acquired after exposure to some learning experiences and subject matter knowledge. Eshun and Mensah (2013) assert that cognitive domain mainly emphasizes remembering or reproducing information, which has been learnt. This domain is knowledge or mind based. As noted by Obemeata (1984), this assessment practice neglects the assessment of skills, which are normally associated with personality characteristics of students whereas complete assessment must cover all the three domains of educational objectives.

It is important to emphasize that every teaching and learning exercise should empower the learners to acquire skills that will enable them to become useful members of society, and not just develop the mental ability of the learner. As stated by the National Council of Educational Research and Training (NCERT, 2006), the objective of education is the complete development of personality including ethical growth which is important for responsible decision making in case of moral conflicts. However, the type of education that society offers is more cognitively focused and this does not enhance the holistic development of the learner. This model of education puts exclusive focus on the cognitive domain to the total neglect of the affective domain and presents alienation between head and heart. Students are nurtured in a spirit of excessive competition and are trained right from the beginning to relate to aggressive competition and the facts detached from contexts NCERT (2006). Hence, educational activities must improve the *humane* qualities of the learner, especially the ability to function effectively in society amidst various challenges confronting members of society. These qualities should include the ability to: innovate and create solutions to problems; improvise when there is scarcity of resources; provide leadership when the need arises as well as function as an ordinary member of a group; and promote good relationship and interaction between man and the environment.

Conclusion

If we believe that knowledge consists of learning about the real world, then we must endeavour to, first and foremost, understand the world, organize it in the most possible way that is rational enough, and as education stakeholders, present it to the learner. This process will involve the consideration of the normative and non-normative aspects of knowledge, especially in the case of science education. Studies suggest that there seems to be a hegemonic concentration on the non-normative aspects of science content and skills by science education stakeholders. This is further demonstrated by the failure to appreciate the distinctively temporal, cultural, economic, and political nexus of social patterns that constitute students' epistemological views (Zeidler, 2014). Therefore, in line with the suggestion of Sadler and Zeidler (2009), precise attention to contextual, sociocultural and socio-scientific perspectives is required for the formation of a completely advanced feeling of scientific identity that essentially entails the enactment of moral responsibility. This is perhaps a controversial opinion. However, it is consistent with other sociocultural views of developing a scientific literacy, and subsequent scientific identity (Brown, Reveles & Kelly, 2005). This may still enable teachers to expose the learners to hands-on learning activities which provides meaningful opportunities to experiment and manipulate the objects of the real world.

This paper argues that scientific inquiry is performed within the bounds of the social enterprise and thus is influenced by society. Therefore, the teaching of science especially at the lower and secondary/high school levels must incorporate socially acceptable values such as morality and sociality. Although wary of falling into the debate on the relativism of scientific knowledge, this paper concurs with the position of Fernández, Benitez and Romero-Maltrana (2022) which stated that some of the social characteristics of science, which are also practiced by other human activities, could propagate the belief that science is as consistent as any other epistemic source. However, science possesses certain unique characteristics such as social endeavour that are possibly exclusive to its activity, and which promote it as the most dependable source of knowledge and protect it from the debate on epistemic relativism. Therefore, it is essential to include these vital elements of the scientific activities within science education in general, that is, not only within the context of formal schooling, but also for society in general (Fernández, Benitez & Romero-Maltrana, 2022). This is within the roles of science education.

To achieve the key strategic imperatives stated above, classroom instruction must incorporate innovative hands-on activities which emphasize the development of improvisation skills. This can be achieved through the utilization of locally sourced recyclable materials that can be easily sourced from within the environment. The intention has always been to make knowledge clear to the learner. We help the learner understand the world. The task of the teacher is to make clear to the learner the working principles that govern the world, with clear distinction of the various components of the world, and how these components interact to ensure the sustainability of the world. In order to accomplish this task, the teacher must present the content of learning in the most appropriate way that would enable the learner to discover these working principles of the world and to be able to utilize these principles to improve society. The pedagogical affordances of the utilisation of contextually relevant instructional strategies and socio-scientific issues based instruction have been highlighted. These pedagogical strategies are necessary as they promote elements of the sociality which we need to achieve through science education.

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