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Shaping Educational Approaches for Tanzanian Students: Assessing Student Responses in a Science-Religion Survey

Malcolm S. Buchanan
Independent Researcher, Brisbane, QLD, Australia.

Corresponding author: Malcolm S. Buchanan (malcolm.s.buchanan@gmail.com)

ABSTRACT

Interdisciplinary perspectives are vital for holistic education, and a pivotal area is identifying positive ways to enhance student perceptions of science and religion relationships. A survey conducted at St. John's University of Tanzania explored perceptions of science-religion interactions and evolutionary theory, while attempting to ascertain what sources influence undergraduate sentiments about science and religion. Results pointed to prevalent negative beliefs about evolution and science-religion relationships. Additionally, exploratory factor analysis suggested that students with the most positive science-religion perspective identify the influence of university education in shaping such beliefs. This paper reflects upon the educational significance of these findings and suggests pedagogical approaches to address these contentious issues within science education in Tanzania, which can potentially be applied to other African contexts. Within a collateral learning theoretical framework, a key component in the proposed conceptual framework is embracing Afrocentric criteria, including 'other ways of knowing'. One approach is a 'pre-assessment questionnaire' and an important aspect is being attentive to students' stories about their current understanding of science-religion interactions and the factors which have influenced these perceptions. The other two pedagogical approaches described are 'first literacy language as a scaffolding tool' and 'science storying'.

INDEX TERMS Science, Religion, Pedagogy, Tanzania, Africa, Education

1. INTRODUCTION

Students in general have difficulty working across different disciplines and synthesizing knowledge from these divergent fields [1 p366]. This in turn brings a challenge to interdisciplinary thinking and education. The challenges students face may be due to disciplinary variations in epistemologies, dialogue and teaching techniques, as well as differences in student learning style preferences [2 p382]. An interdisciplinary area which is of great interest and much written about by scientists, theologians, historians and philosophers is science and religion [3-5]. Science and religion have been an internationally recognised cross-disciplinary challenge for both secondary students [6,7] and tertiary students [8,9]. Within these sources aspects which hinder students from integrating knowledge between science and religion were identified as: contradictory claims of science and religion, lack of skills to study the relationship in depth, subject and classroom cultures, lack of teacher and curricula flexibility to cross disciplinary boundaries, rejection of the theory of evolution, and teacher and student philosophical biases. This highlights the need to increase student epistemic insight and promote interdisciplinary learning.

In 1988 Barbour proposed four well known models for the relationship between science and religion (conflict, independence, dialogue, integration), however, defining a model for the relationship between science and religion is beset with difficulties [3 pp45-50,10]. There are significant differences between the natural sciences, dissimilarity within and between different religions, and also the complexity of history to consider. Furthermore, not just academic but social and cultural aspects are important, as they play a significant part in understanding how religion and science interactions work out in practice. The conflict model puts science against religion. When there are rival statements about the same topic then there must be a choice between science and religion. This model is held by both the scientific materialist and biblical literalist. In the independence model science and religion are compartmentalised. They are independent fields of study or spheres of reality which do not communicate. Science is concerned with 'how' questions, whereas theology is

concerned with 'why' questions. Next there is the dialogue model which presents fruitful relationships leading to an enhanced understanding of both science and religion. Dialogue explores similarities in presuppositions, methods, and/or concepts between science and religion. Lastly, integration proposes that the truths of science and religion can be integrated into a more complete 'whole'. There are three versions of integration: natural theology, theology of nature, and process philosophy. In more recent years Ted Peters (2018) has provided a commendable updated list of ten models for relating science and theology [11]. The approach applied by the author (M.S.B.) most closely aligns with the 'dialogue leading to creative mutual understanding' model of Peters, albeit there is some blending with the other non-warfare models, in particular theology of nature. More specifically, the science-religion approach used here involves respectful conversation over shared areas of interest where both science and religion each have their own complementary perspective. It is also understood that although theology originates outside of science, some doctrine can be modified in the light of scientific findings. Hereafter, when the concepts 'positive' and 'negative' perceptions are applied to the various perspectives then 'positive' implies 'harmonious' and 'negative' means 'conflicting' views on the relationship between science and religion.

The aim of this study is to identify pedagogical techniques for teaching science-religion relationships within the Tanzanian educational context. This has been formulated in response to the findings of a science-religion survey at a university in Tanzania [12]. This study, therefore, responds to the following central research question: Are there any pedagogical techniques to recommend for learning about science-religion relationships within the Tanzanian educational context?

The methodology used was a research synthesis [13 pp427-439]. This approach included analysis of reputable academic sources, extrapolation from personal experience (M.S.B.), and consideration of the educational significance of the findings of a small 2015 science-religion survey conducted at St. John's University. This review was designed to identify approaches beneficial for science-religion pedagogy in Tanzania. A philosophical basis of critical realism, in line with that described by philosopher, theologian and educationalist Andrew Wright, underscores the study. [14 p167]:

Critical realism allows for a richer and more holistic approach to knowledge. The epistemological role played by informed judgement allows our knowing to embrace the realm of meaning and value as well as that of scientific fact. By placing a hermeneutic of faith alongside a hermeneutic of suspicion the critical realist is able to affirm that knowledge proceeds directly from the fact that we indwell a world with which we are already intimately related. Because we are bound up with the world, and because our knowledge is always to a greater or lesser extent provisional, our understanding always proceeds from the givenness of that which we already know.

An important aspect of critical realism which is pertinent for this study is its more holistic and transformative approach to knowledge [15,16]. Therefore, a critical realist approach to research involves identifying interconnections between disciplines, such as science and religion, using the knowledge gained in the transformation of others.

The study progresses by summarizing the science-religion survey before the educational significance of the findings from this survey are stated. This assists in the formation of a theoretical educational framework, from which a working conceptual framework for teaching science and religion is proposed. By connecting key concepts, the latter framework provides the means to identify pedagogical approaches, which are designed to foster improved science-religion opinions among Tanzanian students. There is a significant literature on student perceptions of science and religion [e.g., 17], nature of science [e.g. 18], and teaching the relationship between science and religion [e.g. 19], however, a comprehensive review is outside the scope of this present study.

2. SCIENCE-RELIGION SURVEY

In an attempt to provide much needed information on science-religion perspectives in Africa, in 2015 a science-religion survey was conducted at St. John's University of Tanzania (SJUT) [12]. This survey investigated perceptions of science-and-religion interactions and evolutionary theory, as well as any influential sources which might be shaping students' attitudes towards science and religion. The research design was a quantitative cross-sectional survey [20 pp183-201]. Notable conclusions were suppressed as the sample size was small (143 students). Nevertheless, the findings are of interest and provide insights for future research and areas of inquiry.

The results from initial general questions supported prior limited data on sub-Saharan creationism, showing predominant negative beliefs towards evolution. For example, participants were asked 'Do you believe that humans evolved from non-human life forms?', and the response was 59.4% disagreed, 30.8% agreed and 9.8% were unsure [12 p340]. In order to obtain more in-depth information about students' views on religion, science-religion interactions, and evolutionary theory, the survey included 36 Likert-scale items. The outcome clearly showed negative perceptions toward science-religion relationships. In summary, 'the majority of students indicated that science and religion will ultimately be in conflict (85.4%) and that evolution clashes with both the Bible (80.4%) and the Qur'an (52.8%), while agreeing that the acceptance of evolution and belief in God cannot coexist (54.6%)' [p341].

It was also important to find out the potential sources of these beliefs. Thus, the survey questionnaire asked participants to report on what they perceived to be the main factors affecting their opinions about evolution, and queried whether a religious leader or community member had made any statements about evolution. In order to summarize data so that relationships and patterns (latent constructs or factors) could easily be interpreted and understood, exploratory factor analysis (EFA) was performed using SPSS and the series of

36 Likert items [21]. The four factor groupings identified were 'science is positive yet limited, and compatible with religion', 'evolution conflicts with religious scripture', 'evolution is scientific, not doubt causing, and evolution discourse is important', and 'people are capable of being mutually scientific and religious' [12 p342]. Correlations from factor analysis results could be summarised into two initial conclusions [pp343-344]. Firstly, students' perspectives on science–religion relationships were most positive for those who identified the influence of university education as forming their views. Participants with the most negative assessments of science-religion relationships, on the other hand, identified the influence of local religious leaders' teachings as forming their views. Secondly, students' science–religion views are, in many cases, related to religious community members' statements about evolutionary theory; and, furthermore, students with positive views disclosed that their places of worship held events discussing evolution and that these events were largely favourable of evolution. This corresponds to data indicating that peoples' opinions about science are often reflective of the perspective of the communities to which they belong [22 p37].

These conclusions supplement the findings of two prior science-religion projects conducted at SJUT [23,24]. These preceding studies indicated a perceived conflict between science and religion, with perceptions of conflict often being related to understandings about evolutionary theory and queries about human origins. The current religious demographic in Tanzania is limited as religious questions have been removed from government census reports since 1967. A 2010 projection for 2020 from the Pew Research Centre predicted that approximately 63% of the population will be Christian, 34% Muslim, and up to 5% will practice other religions [25].

3. EDUCATIONAL SIGNIFICANCE OF FINDINGS

In view of all the above findings, it can be asked how might such insights inform groups of people concerned about science education in Tanzania? To answer this question in terms of the limited sample, three considerations are offered. Firstly, pre-university learning, and the teaching of religious leaders, are the most influential in forming students' science-religion views. However, students with positive science-religion opinions are mostly influenced by university education. One possibility is that university instructors are more influential at guiding positive opinions towards science and religion. Secondly, students' science– religion views are, in many cases, related to religious community members' statements about evolutionary theory, which have been found more likely to be negative than positive. Thus, the opinions of the religious community can have a major influence on whether students' have positive science-religion views. Thirdly, although students predominantly express antievolutionist opinions, and convey science-religion conflict, there appears to be underlying uncertainty regarding such viewpoints. However, organised science-religion events appear to be beneficial in helping to foster positive opinions. In assessing these propositions, a preliminary suggestion is that university instructors consider attempting to engage with the religious contexts and school learning of undergraduates as they teach on science and science-religion topics. The findings further indicate that there is a need to promote positive science-religion interactions, especially for those with negative perceptions of religion-science interactions, who may reject consensus science such as evolutionary theory. Therefore, pedagogical approaches for science-religion education that are particularly fitting to the Tanzanian context will be identified. This will be achieved using a theoretical framework based on Jegede's collateral learning theory.

4. THEORETICAL FRAMEWORK: JEGEDE'S COLLATERAL LEARNING THEORY

Jegede's collateral learning theory[1] is applied with this study as the theoretical framework from which to identify pedagogical techniques for improving learning around science-religion relationships within the Tanzanian educational context (Figure 1) [27]. Jegede [28 p117] defined collateral learning as an 'an accommodative mechanism for the conceptual resolution of potentially conflicting tenets within a person's cognitive structure'.

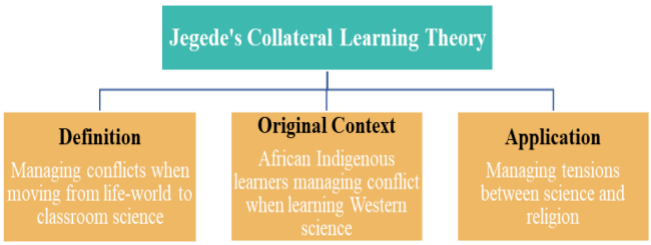

FIGURE 1. Jegede's Collateral Learning Theory

Jegede's model was developed in relation to mathematics and science education in Africa, and within the collateral learning paradigm sociocultural context is an important aspect of the theory [29 pp81-94]. The model also provides an alternative to conceptual change models[2] (cultural assimilation into Western science), and it helps to describe learning outcomes when students, particularly those from non-Western societies, are exposed to the culture of science in the

[1] Jegede's collateral learning theory is not to be confused with the collateral learning conceptualised by the philosopher and education reformer John Dewey (1859-1952) who describes it as the accidental learning that occurs inside and outside the classroom, referred to by others as the 'hidden curriculum' [26 p133].

[2] Conceptual change model (CC Model) – this is a model in which conceptual change is the learning process 'where learners do not merely accumulate more knowledge, but with their conceptions of phenomena in a certain domain undergo a restructuring process, leading from common-sense beliefs to scientific conceptions.' [30 p1411]

classroom along with ideas that may conflict with their own worldviews [27,31]. With collateral learning approaches, the aim is for instructors to make the border crossing from 'home community culture' to 'science classroom culture' less foreign, and to resolve any cultural conflicts and cognitive dissonance.

Jegede described four types of collateral learning, which he identified as the 'parallel', 'simultaneous', 'dependent' and 'secured' categories [27 pp278-280, 28 pp119-121, 32]. Each of these types of collateral learning lies on a continuum that has as its opposite poles the parallel and secured collateral learning categories, with simultaneous and dependent learning in between. Parallel collateral learning occurs when conflicting ideas are held in a student's long-term memory, in a form of cognitive compartmentalization. The conflicting ideas do not interact at all, and they are used independently in different contexts, such that students adhere to one idea or another depending upon their circumstances. For example, students may employ the scientific concept of evolution in science classrooms, but then abide by a conflicting religious concept of creation when in a place of worship. Each conflicting notion is kept as separate and independent ideas that are compartmentally utilised within different contexts. Simultaneous collateral learning is when a concept in one area of knowledge or worldview supports the learning of a similar/related concept in another area of knowledge/culture. Dependent collateral learning is when an idea from one area of knowledge/worldview challenges another idea from a different area of knowledge/worldview to a degree that a student will adjust a current idea without completely changing the current area of knowledge/worldview.

Finally, at the other end of Jegede's continuum is secured collateral learning. In this mode of learning seemingly conflicting ideas interact and are resolved. The learner takes ideas from different areas of knowledge/worldviews which are seemingly in conflict, to bring them together in such a way as to reinforce and enhance each other. As Jegede explained, through secured collateral learning a non-Western 'learner evaluates seemingly conflicting worldviews or explanatory frameworks and draws from them a convergence towards commonality', which strengthens the learning process and secures the "new conception" in the long-term memory' [28 pp120-121]. Notably, secured collateral learning is the ideal situation for improving education around science and science-religion interactions. In many cases a student may need support to advance along the continuum from parallel through to secured collateral learning.

5. CONCEPTUAL FRAMEWORK

The conceptual framework teaching science and religion offers a logical structure of connected concepts that help provide a picture or visual display of how ideas relate to each other within the collateral learning theoretical framework (Figure 2). It consists of an integrated set of philosophical considerations, teaching preferences, and learning values that guides the instructor in preparing effective educational approaches to teaching science-religion ideas in Tanzania. The concepts identified as part of this conceptual framework are: interdisciplinary learning, inquiry-based learning (IBL), culturally relevant instruction with a focus on Afrocentricity, and the limitations of both science and religion. Each of these are now briefly described.

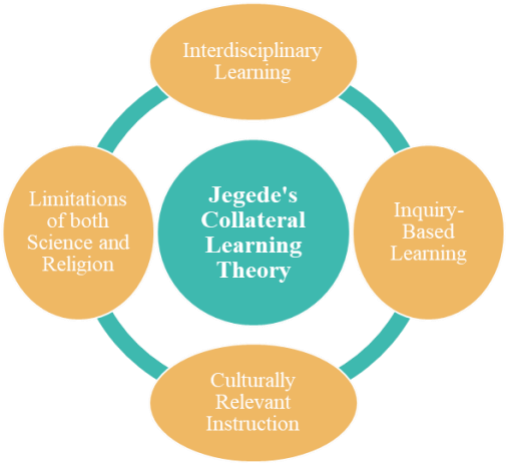

FIGURE 2. Conceptual Framework

5.1 INTERDISCIPLINARY LEARNING

The study of science-religion interactions is by its very nature an interdisciplinary form of learning. Interdisciplinary learning is characterized by combining knowledge from different disciplines around a key problem, issue or theme within an educational program [33]. With regular practice of interdisciplinary thought, learners can 'develop more advanced epistemological beliefs, enhanced critical thinking ability and metacognitive skills, and an understanding of the relations among perspectives derived from different disciplines' [p95]. This acquired boundary-crossing knowledge and skills can then be transferred to other contexts, issues or problems. It has been suggested that the cognitive development and intellectual maturation that comes from interdisciplinary learning may help students to cope with increasingly complex work environments, and may help them acquire in-demand perspectives and problem-solving skills [p109]. Additionally, 'interdisciplinary thinking can be considered as a complex cognitive skill that consists of a number of subskills, such as the ability to change disciplinary perspectives and create meaningful connections across disciplines' [1 p366]. However, students may be challenged by interdisciplinary thinking as a result of disciplinary differences in epistemologies, discussion, and teaching strategies.

5.2 INQUIRY-BASED LEARNING

Interdisciplinary learning naturally lends itself to constructivist inquiry-based learning (IBL). IBL has been defined by the UNESCO – International Bureau of Education [34] as:

> A process that provides opportunities for learners to construct their own understanding of the complexity of the natural and human world around them. Many models of inquiry-based learning share some common features such as: investigation into a relevant issue, problem or concept; a learner-centred approach; the discovery and examination of the complexity of understanding and the involvement of thinking and reflection in the learning process.

IBL is usually arranged into different inquiry phases that link together in an inquiry cycle. Pedaste et al. [35] conducted a systematic literature review on variations of the cycle, to produce a synthesized inquiry cycle with the following four consecutive inquiry phases: Orientation, Conceptualization (alternative sub-phases: questioning, hypothesis generation), Investigation (sub-phases: exploration or experimentation leading to data interpretation), and Conclusion. Additionally, Discussion (sub-phases: communication, reflection) is the fifth phase and occurs at any time during (discussion in-action) or after (discussion on-action) the IBL cycle. An open-minded inquiry approach generates curiosity, and students are led to construct meaning for themselves within an educational context, under the guidance of the instructor [36]. Students engage with problems and questions, while also posing their own questions, and then identify appropriate methods to address these problems and queries. This, therefore, is a particularly suitable approach to investigate science-religion interactions when there exists perceived conflict between scientific concepts and religious ideas, as indicated by the survey data [12,23,24]. Inquiry is known to increase student engagement and improves analytical, creative and critical thinking skills [37,38]. Furthermore, IBL is significantly influenced by a student's culture, which shapes the way students approach intellectual processes [39].

5.3 CULTURALLY RELEVANT INSTRUCTION

There is a need for culturally responsive teaching practices in African classrooms that have inherited Western-style education systems. Otherwise, education may be biased towards the Western cultural predispositions and forms of meaning-making at the expense of African contexts [40]. Culture has a significant influence on teaching and learning, while culturally relevant pedagogy 'empowers students intellectually, socially, emotionally, [spiritually] and politically by using cultural referents to impart knowledge, skills, and attitudes' (Ladson-Billings, 1994, as cited in Boutte et al. [41 p3]). A number of researchers, including scientists [41-43], have practised culturally responsive pedagogy. All cultures in a classroom benefit from each other by providing a mutual exchange of knowledge and cultural understanding. It is important for instructors to be culturally competent, not only in culturally diverse classrooms [44], but within any cross-cultural context. Wlodkowski and Ginsberg [45] rightly contend that culturally responsive teaching strategies should be based on development of student intrinsic motivation, so that students will be able to recognise that what they are learning is both culturally coherent and important.

Within this study, the culture of relevance is Tanzanian. Notably, when it comes to Tanzania and other African nations, the decolonisation of science education has become a theme of growing importance [46]. A significant part of this decolonization is grounding curricula in the experience of local communities [47]. Furthermore, in education, the idea of Afrocentricity entails that instructors allow students the opportunity to study different disciplines from an explicitly African worldview [48 p171]. Afrocentricity serves as a reminder that the frequently dominating non-African Western voice is just one among many, and it is not always the most important or most informed voice [49 p388]. Afrocentricity also recognises that meaning is created, and understandings of the world are developed, from specific sociocultural perspectives and historical experiences [50 p274]. With the notion of Afrocentricity, meaning-making is considered transsubjective, such that knowledge and meaning is considered to be produced within the group experience. By the same token, Afrocentricity takes meaning making to be intersubjective. This denotes that knowledge and meaning production occurs between individuals. Through Afrocentricity, the educational experience is considered to be living and dynamic, by which an individual learner is not separated from the phenomenon or experience being studied (transactional approach) [51]. The philosophical model of Afrocentricity is contrary to Eurocentricity and is displayed in Table 1.

Principally, the Afrocentric framework asks whether there are 'other ways of knowing?' This can include ways of knowing which, perhaps, researchers in science education have missed by conducting their studies within a Eurocentric frame of reference [50 p276]. Afrocentricity also includes a notable openness to affect. Akbar [53 p410] has correspondingly maintained that this 'focus on the affective in Afrocentricity does not prevent recognition and use of rationality'. Instead, affect, 'as a means of knowing, is viewed as offsetting the use of rationality'. Table 1 reveals that knowing through emotion is particularly relevant in African cultural contexts, and Afrocentricity takes such emotionally engaged learning seriously. Though affect and science may be viewed as being contradictory within Western scientific education, Schaefer [54 pp6179]3 has suggested that science is influenced by the guiding emotionality of our human bodies and minds. In other words, science is guided by emotional priorities that link cognition into a network of information and inspiration. Consequently, incorporating Afrocentric perspectives into science and religion education can benefit pedagogy and connect science-religion topics with African worldviews.

[3] Also, renowned philosophers David Hume and William James had an epistemology that makes emotion central to the generation of knowledge (including scientific).

Table 1. Afrocentric philosophical model [49, 52 pp152-153, 53].

Philosophical category	Afrocentric view
Cosmology (Metaphysics)	Reality has an interdependent cosmological perspective. That is, all components of the universe, such as people, animals, inanimate objects, and so forth are perceived as being interconnected. Furthermore, reality is viewed as being both spiritual and material i.e. there is no separation between the spiritual and the material.
Ontology (Metaphysics)	All components of the universe, including people, are spiritual. Here, spirituality is understood as the non-material, or invisible, substance that connects all elements of the universe.
Epistemology	Considerable emphasis is placed on the affective way of obtaining knowledge — knowing through emotion or feeling is considered valid and critical. In other words, the lived experiences of the person, in concert with emotion or feelings, are bases of what are deemed to be true. Knowledge is validated through a combination of historical understanding and intuition i.e. knowing is both rational and superrational.
Axiology	Harmonious interpersonal relationships are valued and a human-centred perspective toward life is offered, rather than an object- or material-centred perspective. In the Afrocentric framework, the value of maintaining and strengthening interpersonal relationships replaces the concern over acquiring material objects and accumulating wealth.

5.4 LIMITATIONS OF BOTH SCIENCE AND RELIGION

An important aspect to consider when developing pedagogy for science-religion dialogue are the limitations of both science and religion as disciplines of study. Broadly speaking, contemporary science is distinguished by its systematic methodology for studying the physical world, with the aim of producing reliable explanations of material phenomena [55]. Science's systematic methodology involves the continuous processes of collecting data via observations, identifying patterns and regularities with accrued data, constructing theories, and making predictions, all of which are influenced by researcher assumptions [56]. Science is further identified by its commitment to methodological naturalism. This epistemological tenet limits scientific reporting to natural systems and materialistic explanations, which involves the eschewal of non-natural descriptions of the physical world. Altogether, it is important to note that science does not prove something nor provide final answers, but instead builds evidence to provide more detailed and accurate descriptions of the physical world. The epistemic scope of the natural sciences, therefore, is limited to empirical evidence, which in turn should limit their explanatory remit. Accordingly, the natural sciences can involve the discovery and identification of so-called 'laws of nature', but the sciences seem limited by an inability to explain why such 'laws of nature' might exist in a philosophically cogent manner [57 p138].

Additionally, there are numerous scientific disciplines, each with their own characteristic methodologies [3 p4]. When it comes to religion, each field may also have different degrees of relevance to people's own religious beliefs. Watts [58 p127] stated 'There are many different sciences, and each has its own history, methods and assumptions. Each also has a different relationship to religion.' Moreover, scientific theories are always being tested and refined, thus are provisional explanations of observed facts which are evolving over time, and therefore makes theories unfinished works in progress [59 p623]. Unfortunately, it has been found that these nuances of science are rarely comprehensively taught [60]. For example, the epistemological and ontological presuppositions of science are seldom communicated, though doing so would likely improve student education [61 p439].

Out of all the areas of knowledge, religion is perhaps the most complicated and contentious [62 p528]. Superficially the epistemic scope of religion is methodologically limited to religious experience, in other words metaphysical propositions and not empirical propositions [p515]. However, religious epistemology is more complex than this description [63]. There are questions over how religious experience should be interpreted, bearing in mind the different religious traditions, and also which experiences can be regarded as valid [62 pp516-517]. A religious faith can be thought of as a paradigm where religious experience is interpreted [pp516-524]. Faith can be as rational as science, for example, the rational arguments for God's existence, such as from 'design' and 'cosmology'. Boone [64] has argued that religious faith has empirical features of being based in past experience, tested in the present, and held tentatively. Science itself has an element of faith as scientists must have faith that the universe is orderly and that humanity has the ability to discover the order [62 p529].

Within this aspect of the collateral learning framework it is important to be aware that science, natural science or modern science, is a recent 19th century development and should not be treated synonymously with older understandings

of nature such as 'natural history' and 'natural philosophy' [65 pp81-106]. Similarly, religion is a relatively modern construct and emerged about 150 years before science during the European Enlightenment. The majority of works discussing the relationship between science and religion deal with science and Christian theology [p98]. Theology and science represent human interpretations, thus temporary and imperfect statements of a deeper truth and reality [66 pp28,36]. This means there is a need for epistemic humility, recognising that the human mind is limited in what it knows and understands. Harrison has stated 'This is not necessarily to say that scientific knowledge is socially constructed: rather, it is the category "science" – a way of identifying certain forms of knowledge and excluding others – that is constructed…… However, an inevitable consequence of the construction of the category is that science will have a disputed content and contested boundaries.' [65 p90] Also, religion and science address similar questions, but respond to them differently giving a deeper understanding of a reality than each on their own [3 p1-5]. With these questions science generally asks 'how' while religion asks 'why' i.e. science is about 'mechanism' while religion is about 'meaning'. A rigorous understanding of the limitations of science and the limitations of religion will promote a deeper understanding of the complex interactions between science and religion.

6. PEDAGOGICAL APPROACHES

The theoretical and conceptual frameworks just discussed are culturally responsive educational models which are beneficial for science-religion pedagogy in Africa. Thus, inquiry-based pedagogical approaches are recommended that have an interdisciplinary and culturally relevant nature embracing Afrocentric ideas. What follows are three theoretical examples of using interdisciplinary culturally relevant science teaching for bridging the gap between university instruction, ways of knowing, and realities within the home community. In this present paper there is only scope for these approaches to be introduced. There is a need for them to be further developed, including the use of data-driven science education research to assess effectiveness.

6.1 PRE-ASSESSMENT QUESTIONAIRRE

Towards the beginning of either a particular unit of study, an academic year, or even an academic program, whichever is appropriate within the educational context, distribution of a science-religion questionnaire is proposed. This will occur once the instructor has established a safe learning environment. The exact nature of the questionnaire will be dependent on the educational context; however, questions dealing with the following aspects are recommended: basic demographic information, religious affiliation, God's interaction with the natural world, compatibility of science and religion, origin of the universe, influences affecting science-religion views, and questions students have on the science-religion topic. Students should be advised that the questionnaire is to provide formative information to the instructor and questions have a 'don't know' option if they are not knowledgeable or comfortable to respond to a particular question. Completing the questionnaire should not take too long and probably no longer than 20 minutes. In conducting this process, instructors need to be self-aware of their assumptions, especially those underpinning their worldview, recognise whether these are creating a tunnel-visioned, subjective interpretation (e.g. ethnocentrism) [67].

From the questionnaire, instructors become aware of students' stories and can assess students' pre-established notions of science and religion and importantly any underpinning worldviews. Such information is needed to convincingly deconstruct any pedagogically-hindering ideas of conflict, and formulate how to best teach scientific subject-matter. This involves being sensitive to what students are hearing from religious leaders, community members, and media voices, as well as what they have been taught at school, while taking into account potential idiosyncrasies associated with religious affiliations. Traditionally in Tanzania many sources of information are authoritative (ancestor spirits, parents, religious leaders, schoolteachers) with little freedom for questioning or evaluation. Mapadimeng [68 p4] quoted Horton in his work 'an obstacle to progress within the African traditional cultures lies in their reluctance to question the established beliefs owing to the fear that any threat to those beliefs could result in a horrific chaos'. By discovering what students have already been taught, and are still being told, within the communities that they are actively involved in, instructors can ascertain how to best relate scientific premises in a culturally relevant manner. An important goal is to empower students to think and act reflectively for themselves, instead of just agreeing with an authority figure or source. Students are to think critically for themselves about competing ideas by carefully examining the evidence on different sides of a science-religion issue, rather than, for example, uncritically accepting a 'settled issue'.

For example, in Tanzania, science and religion, whether in school or church, are generally kept as completely separate and unrelated topics [24]. Then, when conflict arises between the two, the tendency is to choose religion over science. This represents a bifurcation (either-or) fallacy where a person claims there are two mutually exclusive possibilities and there is the need to choose between the two, when there is at least one alternative. This conflict is unnatural for the African, as in traditional culture, the impulse is to seek harmony, whether that be within families or communities, with spirits, with the environment - in reality, with the whole of creation [69 pp63-102]. Therefore, it is beneficial to listen to and affirm student stories of their science-religion upbringing. An instructor can then begin to deconstruct by asking 'Why choose religion over science in conflict situations?' An answer could be 'Because at this point science is going against God' [24 p6]. At this point it may be relevant to discuss the limitations of science and religion. Students can also be introduced to the example of the church's opposition to Galileo's heliocentric theory, which, at that time, they believed opposed biblical interpretation [70 pp62-63]. Next, present an alternative

argument where the same question about a reality can be answered differently by science and religion; or where science and religion answer different questions, but the answers complement each other. Such inquiry uses complementarity reasoning [71]. This can be illustrated, using the topic of cancer, with the question 'Why do people develop cancer?' Scientifically this can be explained in terms of mechanism (*e.g.* genetic change leading to uncontrolled cell growth) or religiously in terms of purpose (*e.g.* reflections on suffering and evil). Both of these types of answers are valid, but operate at a different levels of reality providing a complementary and enriched response on the topic.

Additionally, in this context university instructors should recognize that, despite maintaining apparently straightforward perceptions of science-religion disharmony, students may concurrently possess ambiguities or hesitancies about such topics as the age of the universe and biological evolution. By drawing upon these uncertainties, instructors may be able to uncover how to best relate scientific principles in ways that address those areas where undergraduates are undecided. With regard to biological evolution, a useful insight is to think of science education having a knowledge and understanding of evolution that leads to an 'acceptance of', rather than 'belief in' evolution, as the best explanation for the evidence [72]. With this, there is no need to challenge religious beliefs. Students can be helped to understand and potentially 'accept' evolution, but not be pushed to 'believe it' [61 p439]. However, this is not removing the element of belief in the development of scientific ideas with associated philosophical pre-suppositions and assumptions. A complexity in this matter is variation in the definition of terms such as knowledge, belief, acceptance, and understanding e.g. some may take a Platonic view of knowledge as justified true belief, while others say there is distinct scientific knowledge which is different from belief [72,73]. Moreover, it is helpful for students to be able to distinguish between biological evolution 'the technical scientific hypothesis' and evolutionism 'a metaphysical philosophy' which is often confused with it (MacKay in De Felipe [74 pp48-49]). In the latter anti-religious philosophy 'evolution' replaces 'God' as the authentic force in the universe.

6.2 SCIENCE STORYING

The human soul is captivated by storytelling and its appeal cuts across culture, generations, ideologies and academic disciplines [75 pp75-79]. Storying is a constructivist pedagogy which is a powerful technique for teaching and learning. Stories can have a variety of purposes in the classroom, which include 'sparking student interest, aiding the flow of lectures, making material memorable, overcoming student resistance or anxiety, and building rapport between the instructor and the students, or among students themselves' [p77]. Science storying is a pedagogical technique by which students are engaged in science learning through story. Storytelling has been regarded as a type of inquiry as it is a collaborative activity, has a qualitative interest and includes holistic perspectives (Reason & Hawkins in McDrury & Alterio [76]). As well as dialogue in different forms, story can also be used 'to help students make connections within and between self and others, subject and object, thought and feeling' [76 p34]. Storytelling has been thought of as another 'way of knowing' [pp35-36] in a similar way to those described by Theory of Knowledge [62 pp72-305]. In other words, it has the ability to reveal, discover, suspend, re-examine or create meaning and to prepare the way for future learning [76 p34]. And this may include the use of metaphor, simile, parable, dramatic action, and more.

Reading stories of science has been used effectively to teach the Nature of Science and the Science-Religion interface at a U.S.A. university [77] and teaching the Nature of Science at a middle school in Turkey [78]. However, the approach discussed here involves oral storytelling which resonates with the oral tradition of African culture [79 pp1-5]. Moreover, human stories are located 'at a more fundamental level than explicitly formulated beliefs, including theological beliefs' [p38]. It can be inferred from this that the power of story can be a useful teaching strategy. Furthermore, students learn that science is a 'human activity', rather than just a complex and abstract discipline [80 pp58-68].

Storytelling helps students remember key ideas, places these ideas in a context, and links them together [80 pp5868]. It can be used to deconstruct erroneous stories and reconstruct the true story. Hutchings gives a good example of this with the inaccurate Galileo 'church verses science' story being retold in a simple, accurate and memorable (SAM)[4] 'two guys tricked everyone' story [pp62-68]. The two guys are John Draper (1811-1882) from the University of New York and Andrew White (1832-1918) from Cornell University. They wrote the books 'History of the Conflict between Religion and Science' (1874) and 'A History of the Warfare of Science with Theology in Christendom' (1896), respectively, which successfully introduced the erroneous idea that science and religion (especially Catholicism) are at war. This dramatic oral storytelling approach is naturally interdisciplinary, the Galileo example involves not only science, but also religious studies, drama and history.

The first step in this storying pedagogy is to select a suitable story that will express important truths in the science and religion relationship. Then research is required to gather accurate information on the topic. Using this information, an uncomplicated, accurate and memorable story is crafted so that it can be told dramatically within about two minutes. It is important that the science storying is followed up with strategic discussion questions. These questions will vary depending on the learning goals. A 'group conversation method' can be used for discussion, which is based on the

[4] A Wycliffe Bible Translators acronym used in 'Story the Bible' workshops.

central principles of dialogue and dialectic, characteristics of the oral history of African people (Asante in Hawkins & Thompson [50 p279]). The instructor can go around each group guiding the discussion where needed, helping shape ideas or opinions, and then at the end there can be a summing up with the whole class. This pedagogical approach can be used not only in the Tertiary classroom, but also adapted for use within local communities, for example in a local school or organised church meeting. This is important as the Aechtner and Buchanan [12] survey has shown that the opinions of the religious community can influence students' science-religion views.

Amongst the science stories, an important story to tell is the instructors' personal story of how they arrived at their present understanding of the science-religion relationship. This helps students see how the instructors' views have changed over time. An 'I used to think' approach is useful here [61 p437].

6.3 FIRST LITERACY LANGUAGE AS SCAFFOLDING TOOL

Swahili was introduced as the Tanzanian national language at independence (Tanganyika – 1961; Zanzibar – 1963; formation of United Republic of Tanzania – 1964) [81]. This was initially in opposition to English as the dominant language. Before independence Swahili was firstly identified with Islamic culture, and secondly as a lingua franca. Tanzania has over 120 ethnic groups speaking different languages in their local communities, thus the main drive for Swahili becoming the national language was the unifying potential of the language. The language of instruction in Tanzania has always been controversial, and since independence Swahili was used for Primary education and English for Secondary and beyond [82-84]. It has been reported that the transition between languages has a negative effect on academic performance [82 p1262]. Research by Kinyaduka & Kirwa [85] discovered that most students (69.5%) did not fully understand subject content when taught in English, while 78.9% of teachers regard English language instruction as a hindrance to academic achievement. Recognising the language of instruction challenge, recently, in 2017, Tanzania adopted Swahili as the only language of instruction in schools [86,87]. This was the first occasion a country in sub-Saharan Africa has used an African language as the only language of instruction in schools whereas English remains the main language of instruction for tertiary education..

Proficiency in the language of instruction is key to effective learning, and in the Secondary schools and Higher education classrooms in Tanzania the English competency of most teachers and students is poor [88]. A study has shown that students struggling to learn science in a second language, lose at least 20% of their working capacity 'to reason and understand' in the process of learning in an unfamiliar language [89].

In Tanzania's Tertiary environment where the language of education is English, a pedagogical strategy is to use Swahili as a scaffolding tool in complex content statements to make sense of science content and the English language. A scaffolding tool is a technique used to enable learners to complete a task successfully and more independently by modifying the level of support to fit the learner's current ability [29 p89]. This has previously worked well while using the first language (English) to teach science in a French immersion context [90].

In the case of science-religion dialogue (*i.e.* engagement between the two disciplines) students can be supported with vocabulary, clarification of concepts, and comprehension of questions and other tasks. Considering a possible example, under the topic of biological evolution: *vocabulary* such as perspective, literal, mechanism; *concepts* such as creationism, intelligent design and theistic evolution; *comprehension of a question* like 'How would you counsel a friend who believed that accepting the principle of the scientific theory of evolution meant giving up their faith in God?', have a certain complexity that may need scaffolding using Swahili. Care is needed not to overuse, nor become dependent on the first language, but rather to use it optimally. Apart from supporting learning, first language use enhances interpersonal interactions and reduces insecurity because of limited language proficiency [91]. This pedagogy is a form of culturally responsive teaching, as including the first literacy language as a scaffolding tool creates a climate of caring, respect and valuing of students' cultures [92 pp117-118].

7. CONCLUSIONS

A 'pre-assessment questionnaire', 'science storying' and 'first literacy language as a scaffolding tool' are three recommended pedagogical strategies to support positive science-religion interactions in Tanzania and which can potentially be extrapolated to other African contexts. Knowledge domains, including science and religion, are complementary and interconnected and learning is enhanced when students acquire the skill of connecting what they know, rather than seeing knowledge as isolated parts without relationship [93 pp128-129]. The present study provides information to guide further research (including data-driven) and provide potentially useful insights for science instructors worldwide.

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BIOGRAPHY

Dr Malcolm S. Buchanan is currently a Secondary Science and Mathematics teacher in Queensland, Australia schools, with principal area of expertise, chemistry. His roles over the years have included Senior Research Fellow at Griffith University, involved in drug discovery research, and Associate Professor at St John's University of Tanzania (SJUT), Dodoma, Tanzania. Current research interests are in the areas of science education and science–religion interactions.