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SAUDI CHILDREN'S TAXONOMIC KNOWLEDGE OF ANIMAL SPECIES

Fayadh Hamed Alanazi

Abstract. *The purpose of this research was to explore and compare the ideas of Saudi boys and girls on animal species. Eighty-four children (comprising 42 boys and 42 girls), aged nine years, from four primary schools, participated in structured interviews to determine their ideas pertaining to taxonomic labels, namely 'animal', 'fish', 'amphibian', 'reptile', 'bird', 'mammal', and 'insect'. The results demonstrated that Saudi children of both genders display a wide range of alternative conceptions; more specifically, the effect of gender was significant for all taxonomic vertebrate labels, suggesting that Saudi boys have better knowledge relating to animals than girls. However, generally, children did not have adequate forms of reasoning for biological classification. It was also found that none of the fourth graders thought of humans as animals due to the Islamic science worldview. Based on these findings, it is argued that science education, notably in an international context, should strive to incorporate an understanding of local values and beliefs.*

Keywords: *early year's science, animal taxonomy, socio-cultural perspective, Islamic science worldview.*

Fayadh Hamed Alanazi
Jouf University, Saudi Arabia

Introduction

The research of students' conceptions of natural phenomena has become a central issue in science education for many years. This is mainly because children tend to bring their own ideas and understandings about science into their classrooms (Driver, Guesne & Tiberghien, 1985; Osborne & Freyburg, 1985). Studies of how animals are conceived of and classified have pointed out that children have many alternative conceptions of scientific classification (Chen & Hsiung, 1998; Inagaki & Hatano, 2008). Students tend to hold intuitive ideas and beliefs about concepts or phenomena, which can be false or non-scientific. Yet these alternative conceptions form the basis for understanding new information and can thus lead to misunderstandings of other subjects (Aldahmash & Alshaya, 2012).

In modern society, increasing emphasis is placed on understanding biodiversity and ecology. This leads to the expectation that people can recognise and identify particular species of plants and animals, and correctly place them within taxonomic groups (Allen, 2015). Yet, even though the concept of 'animal' is fundamental to biology, studies suggest that misconceptions abound, and students' abilities to reliably classify animals taxonomically are poor (Chen & Hsuing, 1998; Allen, 2015). Assaraf, Eshach, Alamour & Orion (2012) argue that, rather than viewing conceptual change processes through the limiting lens of the 'classical approach', student misunderstandings need to be viewed in broad terms that take into account socio-cultural factors (Leach & Scott, 2003).

The 'socio-cultural' view posits that conceptual changes occur in multiple and varied contexts and are supported by cultural artefacts and tools; in contrast, the classical approach has a much narrower focus, placing emphasis on internal cognitive processes (Assaraf et al., 2012). Shahrani (1995) finds that eleventh-grade Saudi students had poor understanding of inheritance, which was directly informed by socio-cultural factors. Hence, this research revealed that the prime sources of students' misconceptions about the natural phenomena were textbooks, teachers, and socio-cultural factors.

In 2008, in cooperation with the Obeikan Research Development Company, the Saudi Ministry of Education rolled out a new maths and science curriculum (Alghamdi & Al-Salouli, 2013). The new science curriculum is, to an extent, based upon translated textbooks provided by McGraw-Hill, an American publisher. Obeikan Education has an arrangement with McGraw-Hill that allows the former to translate and localise McGraw-Hill maths and sciences

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texts for kindergarten to grade 12; these are sold across the Arabic Region to education ministries (Aldahmash & Alshaya, 2012). However, Alshammari (2013) asserts that culture and society are different in Arab and Western countries. Because of this difference, some researchers have disputed the appropriateness of adopting curricula from different countries (Haidar, 1999). The evidence suggests that transferring Western-orientated science materials to non-Western contexts is ineffective, because the content is misaligned with the knowledge students derive from their cultures (Alshammari, 2013).

In non-Western countries, those students who hold strong views as to the indigenous belief system adopted by their community -whether it be anthropomorphism in Africa or magic in the Solomon Islands- may consider the science curriculum to be a form of cultural violence (Aikenhead & Jegede, 1999). Learning about Western science does not equip non-Western students with the information necessary to explain local environmental phenomena (Alshammari, 2013). Hence, the current research contributes to a large body of evidence suggesting that a successful science curriculum must take into account the culture and society in which it will be taught.

To follow science curricula effectively and deliver material about living organisms to which young children can relate, teachers need to know what children's baseline knowledge is when they start formal education (Allen, 2015). A number of studies have explored students' knowledge about particular groups of animals, mainly vertebrates (Tunnicliffe & Reiss, 1999) including birds (Prokop, Kubiatko & Fančovičová, 2007), amphibians and reptiles (Yen, Yao & Chiou, 2004) and a few have focused on spiders and insects (Shepardson, 2002).

Although other research has studied misclassification in older children and adults both quantitatively and qualitatively (Allen, 2015), a review of the educational literature to date reveals no attempt to explore Saudi children's understandings of the classification of animals from a socio-cultural perspective. Alternative science concepts are universal; they are found in boys and girls of all ages, abilities, social classes and cultures (Prokop, Prokop & Tunnicliffe, 2008). However, due to the influence of Saudi culture and religion, all schools are single-sex in Saudi Arabia. This gender separation also means that it is obligatory for many Saudi education researchers to conduct single sex studies. Differences might exist between boys and girls due to the ways in which individuals are socialized based on their gender. The inclusion of girls as participants in this research may reveal new and important issues in Saudi education. This research is therefore both challenging and particularly significant, as there is no other published research on children's understanding of animal classifications in Saudi Arabia that examines gender differences.

Students' Understandings of the Classification of Animals

Much research has explored into children's abilities to categorise animals, with students of different primary years commonly creating animal groups in line with various statuses, such as those organisms that can fly and those that live in water. An animal's habitat is recognised as a fundamental criterion, more so than taxonomy, when it comes to primary school children (Kattmann, 2001), with large mammals notably recognised as fish. As Carey (1985) points out, marine life is isolated and therefore can be separated from other animals owing to their natural habitat in the sea.

In the case of upper primary years, students are more likely to utilise mutually exclusive groups in line with observable concepts and features. Importantly, students' ability to apply a hierarchical categorisation system for the grouping of animals tends to become apparent in middle school. Accordingly, in the case of younger children, as a result of their apparent lack of experience, they demonstrate a tendency to classify animals only in mind of prototype; when older, however, they take note of examples, and accordingly refer back when categorising (Allen, 2015).

Furthermore, it is recognised that children are more likely to categorise cases through directing attention to only a single characteristic, such as the colour of an object or the number of sides of a shape, rather than taking into account a number of different elements at one time (Wellman & Gelman, 1988). Regardless, however, it is noted that children need to develop the capability when it comes to biological taxonomy. This could be established through teaching of the criteria required in order to assign different species to different groups, and recognising that, when categorising, it is essential that an organism embodies all of the attributes outlined rather than just a select few (Allen, 2015).

Despite the fact that students' ability to successfully classify organisms improves as they get older (Carey, 1985; Goswani, 2008), it remains that their cumulative experiences may also go against, and therefore be a factor in, misclassification (Allen, 2015). As has been noted by Papandreou & Terzi, (2011), children are known to develop their own theories in regard to natural phenomena, with such theories developed in line with: artefacts and tools; direct experiences; books; television programmes; songs; family and community; beliefs; habits; and what is taught at school. As an example highlighted by Bell (1981), students stated that they believed penguins to be mammals due to them providing milk for their young, which could have come from a nature documentary, with chicks seen to hide beneath a parent's body (Braund, 1991). Moreover, such errors are commonly created from picture books and stories (Kubiatko & Prokop, 2009). As a result, it is common for children, in their early years, to develop science misconceptions as a result of natural maturation (cognitive factors, Piagetian perspective, 1929), in addition to exposure to informal and formal learning (socio-cultural factors, Vygotsky perspective, 1962).

The thought processes and knowledge of children are seen to relate to the ways in which they socially interact (Tomasello, 2000), which suggests that a number of individual elements - including language rituals, beliefs, myths, language, geographic location, families, religion and values - all play (Pastorino & Doyle-Portillo, 2012; Tao, Oliver & Venville, 2012). A number of independent language-based and cultural influences that appeared to play a role in the mediation of students' classification decisions was recognised by Allen (2015). This is valuable as a further issue identified is that of semantic similarity between fish and some mammals. As an example, a whale is known to be a 'velryba', which means 'big fish' in Slovakian.

A number of similar issues are highlighted in the work of Trowbridge & Mintzes (1985, 1988), which state that, as a result of the word 'fish' being in the names starfish and jellyfish, such creatures were incorrectly categorised as fish. Accordingly, it may be stated that the names of organisms themselves may be considered confusing. In this vein, it is noted by Gillespie & Gillespie (2007) that the words 'mammal' and 'animal' are often confused by children, and so they therefore fail to categorise birds and fish as anything besides animals. When it comes to amphibians, children also demonstrate confusion when it comes to defining what is amphibious: for example, it is possible for an amphibious vehicle to operate on both land and in water, with all species with a mixed aquatic/terrestrial habitat categorised as amphibious (Braund, 1991).

One further consideration that was seen to arise from the students' responses relates to culturally transferred myths in relation to some animals (Kubiatko & Prokop, 2007; Allen, 2015). Taking bats, as an example, it was common for students to believe that bats consume blood, which created the view that bats are bad for other animals (Kubiatko & Prokop, 2007), with such folklore spanning back many hundreds of years. Such myths have caused people to be fearful of bats (Armstrong, Adams, Navo, Freeman & Bissell, 1995; Kubiatko & Prokop, 2007), and are known to cause people to feel very strong emotions, depending on the degree of familiarity with the animal and the cultural traditions (Armstrong, 1995).

In a number of different tales, Aesop personified bats as manipulative and as unscrupulous liars. Furthermore, the ancient Mayans of Central America created art to signify bats as dogs of the underworld and of darkness (Kubiatko & Prokop, 2007). On the other hand, in Western culture, the owl is considered to be a wise creature, whereas in Arab culture, the owl is depicted as bad luck, with the owl viewed as a night crow (Husni & Newman, 2015). Accordingly, myth is seen to play a significant role in the ideas of students in regard to animals. Cultural and religious beliefs and practices were also seen to be at the root of various other misclassifications, with Tema (1989) stating that children from Botswana were correct in almost all of their categorisations of animals, both archetypal and non-archetypal, except for humans. This posed the view that the children applied anthropocentric reasoning in line with traditional African thinking and Christian instructions, which sets humans and animals apart.

Accordingly, the knowledge of a student ultimately depends on their social and cultural experiences, such as with whom they interact, how they utilise and transform cultural tools, what social practices they apply, and in what traditional activities they partake, etc. (Papandreou & Terzi, 2011). Accordingly, there is a need to direct attention to socio-cultural theory (Vygotsky, 1962). As such, the present research will extend knowledge into the understanding of animal taxonomy, as held by children, from the socio-cultural perspective.

The Significance of Gender

There is a lack of consensus as to whether there are gender differences in children's classification behaviour. Lindemann–Matthies (2005) found that boys expressed significantly fewer alternative conceptions about invertebrates than girls, even though girls out-performed boys in their knowledge of the internal organs of vertebrate and invertebrate animals. On the other hand, Randler, Höllwarth & Schaal (2007) found no statistical difference between the genders but did observe an increase in knowledge about animals associated with participant age.

Prokop et al. (2008) found that girls demonstrated that, compared to boys, they had a better understanding of animal anatomy, and more girls than boys kept animals as pets. However, girls were also more likely to misclassify invertebrates as vertebrates by drawing bones inside the animals. The effect of gender was significant for all

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animals except for the fish, suggesting that girls have better knowledge about animals' internal organs than boys.

Kubiatko & Prokop (2009) found that there were no statistically significant differences for the categories of foraging strategies or senses, morphology and anatomy, although age was associated with mammal knowledge in the category of parental care. In the senses, morphology and anatomy category, girls performed better than boys, but on all other categories boys attained higher scores than girls. These statistically significant results have been replicated in comparable studies (Randler, 2008 cited in Kubiatko & Prokop, 2009).

However, as Hummel et al. (2015) argue, results suggesting gender differences are not conclusive. Although boys have more knowledge about wildlife, no gender differences were found in their knowledge about birds. Indeed, Slovak girls demonstrated greater knowledge of birds than Slovak boys.

The Saudi Context – Islamic Science Worldview

In Saudi Arabia, the education system is regulated by the Ministry of Education. The twelve years of education are divided into three stages: primary, middle, and secondary. The durations of the stages are six years, three years and three years. Biology is a compulsory part of the curriculum at all grades, although in primary and middle school the subject is not taught separately, but rather is included in the general science curriculum (Aldahmash & Alshaya, 2012). Culture and knowledge in Saudi Arabia are strongly guided by the country's religion, Islam (Haider, 1999).

Socio-cultural worldview theories assert that the mind is not isolated from social and cultural contexts (Aldahmash & Alshaya, 2012). The Islamic worldview is centred on the Unity of God or Tawhid; this plays a crucial role in most Muslim cultures in general, and in Saudi culture in particular (see Figure 1).

The notion of Tawhid implies the Unity of the Creation; the Unity of Nature is a reflection of the Unity of the Creator (Golshani, 2005). Golshani (1998, 2003a, 2005) states that in the Qur'anic view (the Unity of Truth and Knowledge), God is the Creator and the Sustainer of the universe. Therefore, certain topics in biology in Saudi Arabia, such as 'genetics, genetic engineering, and heredity, as well as bioethical questions, the theories of evolution, the big bang, have certain controversial implications when taught in the classroom' (Aldahmash & Alshaya, 2012, p.6). Some of these topics are opposed on 'a religious basis especially by illiterate sections of the general population' (p.6). Saudi students' understandings and knowledge of 'biological concepts might be affected by their culture' (p.6).

Islam asserts the essential Unity of Humanity as the result of the oneness of God. Male and female are created from one single soul. The Darwinian perspective asserts that the development of life out of random processes and the emergence of species were not planned; this theory explicates the evolution of species in terms of natural selection (Golshani, 2003b, 2005). Because the Darwinian account of evolution posits natural selection, it is often seen by those with religious beliefs, including Islam, as an alternative for God. Those adopting the Darwinian perspective view humans as complex machines that cease to exist once the material body dies.

With regard to human embryo development, Allah says, in Almursalaat Surah verse "20-23," 'Did We not create you from a base fluid (20) Which We laid up in a safe abode (21) For a known term? (22) Thus, we determined (things) (23)' (The Qur'anic Arabic Corpus, 2009, 77). The Western worldview, in contrast, posits that human beings are composed of both substances, mind and matter (or the mental and the physical), that are separate and independent (Aikenhead & Ogawa, 2007). However, according to the Islamic worldview, human beings combine material, empirical traits with spiritual, non-empirical ones, in an indivisible unity that lasts a lifetime. According to Ragab (1993), the empirical trait is the body and the non-empirical trait is the soul.

Human behaviour is shaped by the dynamic interaction between these two traits. Ragab (1993) adds that Islam's view of the association between body and soul through divine revelation does not deal with spirituality vaguely. Instead, from the Qur'an's worldview (the Unity of Truth and Knowledge), a covenant was made between humans' souls and their Creator before human beings were sent to the world. The covenant was based on the Unity of God, in that He is their One and Only Lord, their Sustainer. The covenant explains the origins of the relationship between humanity and God.

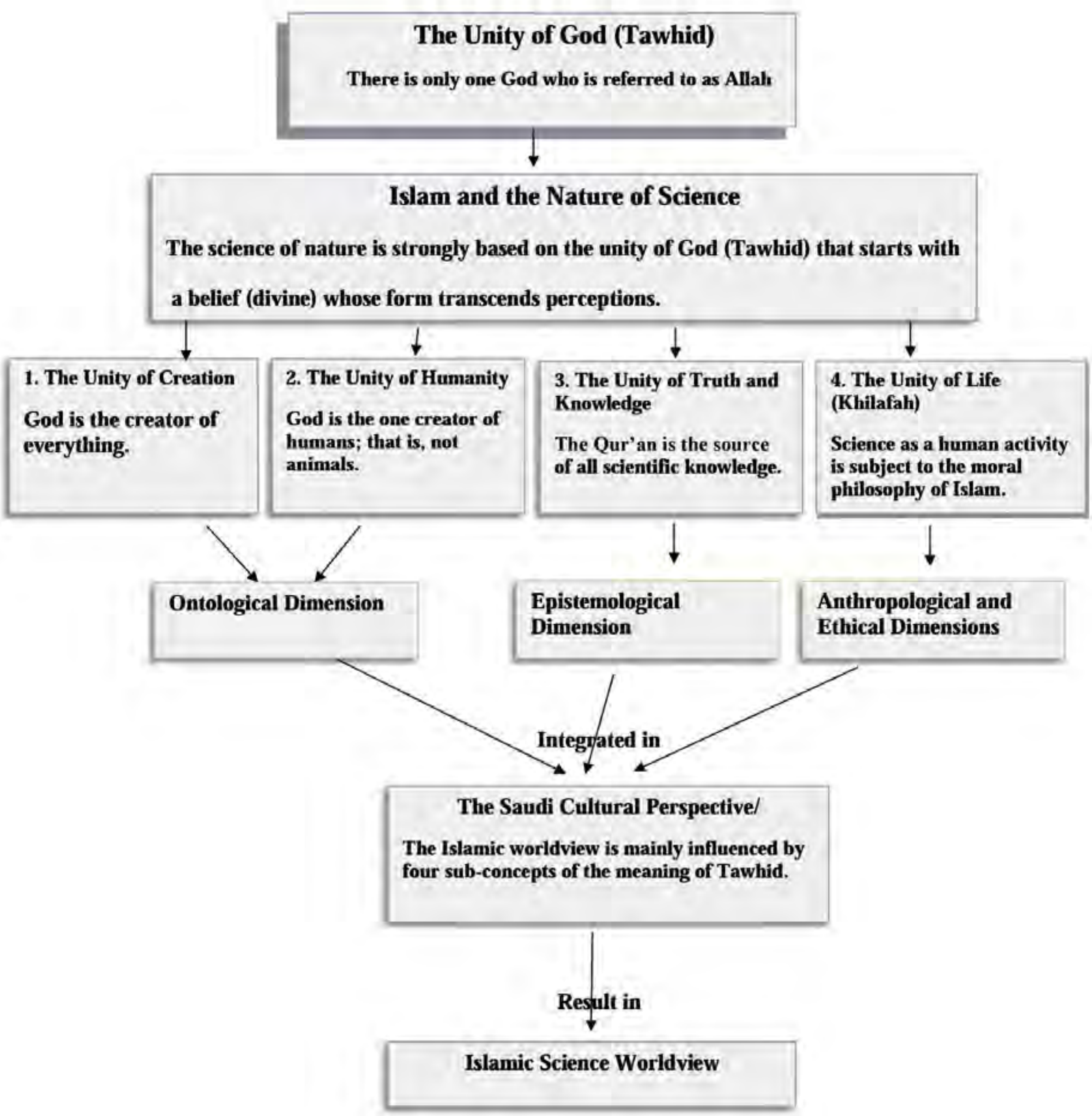

Figure 1: Islamic science worldview based on the Unity of God (Tawhid).

However, Ragab (1993) argues that humans could either retain that original spirituality or go astray by forgetting their God and the covenant. In the Islamic worldview, God sends prophets with prescriptions on how to return to the original covenant. Humans who have kept their covenant intact will follow God's prescription and guidance. They will therefore live good lives and be saved and duly rewarded in the hereafter. In contrast, humans who have dissociated themselves from Him will live miserable lives now and will be duly punished in the hereafter (Golshani, 2000). Therefore, in the Islamic worldview, the spiritual plays a key role in explaining the relationships between humans and their Creator. Hence, there is no Islamic science of humans that would exclude spiritual aspects of human beings (Ragab, 1993).

In many situations, Saudi children believe what is taught in the Qur'an (the Unity of Truth and Knowledge) over science books or scientific theory. Consequently, Saudi students do not recognise people as animals. Similar results have been found in other cultures (Tema 1989; Bell, 1981; Chen & Hsiung, 1998; Ferguson & Kameniar, 2014). For example, Chen & Hsiung (1998) asked thirty-six children from the second, fourth, and sixth grades in aboriginal

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schools of eastern Taiwan to classify animals, such as turtles, frogs, snakes, girls (human) and spiders. None of the second-grade participants and approximately half of the fourth-grade and sixth-grade students identified humans as animals. Similarly, humans were not identified as animals by students in Botswana due to their anthropocentric thinking patterns, which stem from the influence of cultural background based on traditional African thinking and Christian instruction (Tema, 1989).

Further, the Unity of Life is based on the philosophic views of khilafah, which consider humans as stewards of God's estate, who have social responsibility towards biophysical and social-cultural environments. Hence, it therefore is possible that Saudi children think about humans from an Islamic science worldview (see Figure 1), and accordingly consider this worldview as more valuable than scientific ones owing to their faith and the cultural belief that God is pivotal. Aldahmash & Alshaya (2012) argue that the dynamic interplay between the mind and the external environment determines the content of abstract concepts. The construction of knowledge starts with concrete experiences that inform abstract concepts, which in turn feed back to the concrete. According to socio-cultural perspectives, the mind is not isolated from social and cultural contexts.

Problem of Research

The present research argues that cognitive dimensions are enriched with experiential and socio-cultural aspects, the current research therefore seeks to explore children's conceptual understanding of children taxonomic knowledge of animal species from social-cultural learning. Children generally do not have adequate forms of reasoning for biological classification. Students do not consistently use classification schemes similar to those used by biologists until the middle grades. This research therefore argues that there is a need to investigate the sources of Saudi students' alternative conceptions of scientific issues.

Further, Saudi children's knowledge and understanding about natural phenomena are distinctive, complex and rich due to their everyday life experiences and theological knowledge. Religious beliefs have an impact on science education, since myths and religious legends include explanations of natural phenomena that are contradictory with scientific findings. Religious beliefs of the students play a crucial role in their classification approaches especially when the issue is concerning the classification of humans alongside other animals. The present research argue that efforts to improve science education in Saudi Arabia need to take into consideration the fundamental role played by Islamic practices in students' daily lives and activities. Thus, the need to overcome the conflict between non-scientific and scientific knowledge in a way that facilitates the teaching of scientifically and evidence-based facts, such as evolution and rejects the traditional delivery of non-scientific ones. The present research suggests directing towards the various elements assigned to different socio-cultural factors, as opposed to directing attention to the similarities identified in the thought processes of children.

Questions of the Research

The following research questions guided the research:

- Q1: What are the alternative conceptions about classifications of animals held by fourth grade Saudi children?
- Q2: Is there any evidence of gender differences in students' alternative conceptions about classifications of animals?
- Q3: What are the identifiable patterns of classifications of animals held by fourth grade Saudi children?
- Q4: Is there any evidence of gender differences in the patterns of classifications of animals?

Methodology of Research

General Background

This research is conducted in Aljouf City where children and schools have been selected—is a typical city, and therefore shares very similar cultural features with other cities in Saudi Arabia; this means that choosing any region would not be expected to affect the representativeness of the sample. The structured interview was the essential tool of data collection. The tasks included in the interview were validated before implementation. This research is first conducted in Saudi Arabia that uses a statistical approach applied to the frequency and verbal reasons data were thus simple and complex chi-squared goodness-of-fit tests to examine all the target concepts.

Sample

The research was carried out using a sample consisting of 84 fourth graders who were randomly selected from four different primary schools in the north of Saudi Arabia; 42 children were from two girls' schools and another 42 children were from two boys' schools as all schools are single-sex in Saudi Arabia (see Table 1). Recruitment of those participants required some ethical considerations such as obtaining consent letters from children's parents. The researcher hardly managed to get 84 consent letters in order to incorporate those children and it was difficult but even not allowed by school principals to recruit additional number of students. All names of schools were changed in order to mask the identities of the participants involved. Fourth graders were selected for this research as Saudi science textbooks introduce the concept of classification of living and non-living at this grade level. In this grade children also study the general characteristics of: plants and animals; differences between vertebrate and invertebrate animals; animal classification (fish, birds, insect, reptile, amphibian, and mammal); and the arthropod taxon 'insect' (comprising categories such as arachnids, myriapods and crustaceans).

Table 1. Participant characteristics.

Schools	Children			
	Grade	Age	Gender	Number
Abdulla	4th	9 years	Boys	21
Kiald	4th	9 years	Boys	21
Osman	4th	9 years	Girls	21
Mohmmed	4th	9 years	Girls	21

Instrument and Procedures

The classification cards developed by Trowbridge & Mintze (1985) were used throughout the interviews. The following 21 animals were chosen for classification, as they were likely to be recognised by the local children: bat, bee, butterfly, crocodile, dolphin, earthworm, eel, falcon, frog, human, lizard, ostrich, penguin, salmon, snake, shark, spiny-tail lizard, spider, turtle, and whale. Children were interviewed one-to-one in their schools.

Each interview lasted between 20 and 30 minutes. A structured interview approach was applied, such that children were first asked if they could separate the cards in relation to the categories of vertebrates and invertebrates. The researcher then asked children about the reasoning behind their selections.

Interviews were carried out with the aim of establishing each child's understanding of taxonomic labels, i.e. amphibian, bird, fish, insect, mammal, and reptile. Children were asked to complete six simple sorting tasks, one for each label. Children were given as much time as they needed and were allowed to make any changes they felt necessary. Furthermore, they were asked to provide explanations for their selections. The reasons for their assignments to different groups were noted, in addition to any other comments considered relevant or as potentially adding value to the research.

The same procedure was completed across all six taxonomic groups. The cards used in each taxon are detailed in Table 4. It is worth noting that there are cards in the six taxonomic groups, as a result of established common misconceptions of taxa (Trowbridge & Mintzes, 1985, 1988; Braund, 1991; Chen & Ku, 1998; Allen 2105). For example, with regards to the 'fish taxonomy, the cards included were crocodile, whale and dolphin, in mind of exploring whether children group organisms according to their status, such as organisms that live in water (aquatic animals, swimming). Q1 and Q2 were designed to explore the different misconceptions that Saudi children hold in relation to classifications of animals and gender differences, Q3 and Q4 were designed to explore the underlying reasons for misconceptions and gender differences.

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Data Analysis

The data was collected in binary form, and the statistical operations applied to the frequency and verbal reasons data were thus simple and complex chi-squared goodness-of-fit tests. The same tests were used to determine the possible influence of gender on performance. Frequency tables indicate the number of times children in a particular age group correctly or incorrectly matched the animal with the taxon. Prototype-relevant categorisation reason tables were used to record the rationales that children gave for their categorisation choices. The verbal reasons given in the interviews were coded according to theme categories that had been predetermined from previous studies.

Ethics, Validity and Reliability Analyses

Regarding ethical considerations, the parents of the children involved in this research were provided with informed consent forms to read and sign prior to the research being completed. Parents were informed of the research's purpose and what tasks would be carried out. They were also advised that they could withdraw their child from the research at any stage and without providing a reason.

Furthermore, guardians were involved in in-person interviews and in-depth discussions in order to ensure understanding of the research background and processes. Anonymity, confidentiality, and data protected were all discussed and ensured. Importantly, the privacy of the children involved was afforded priority and complete respect.

The content validity of the interview tasks was confirmed through review by more than ten faculty members at Jouf University, as well as supervisors and teachers of science education courses. Reviewers were asked to give their opinions regarding the suitability of the interview content and the research purposes. Three researchers independently coded the verbal reasons data. Inter-rate reliability coefficients were within acceptable boundaries (90.3%).

Results of the Research

The responses given by children were evaluated for how closely their ideas of animal categories matched scientific models of biological taxonomy. Common prototypes emerged from the data collected. Performance measures were combined with the verbal reasons the children gave for their choices. These data are compared to those collected from other studies. In the following quotes from students, 'B means boy and 'G means girl.

Vertebrate

For both genders, in relatively large proportions, falcon, bat, ostrich, and dolphin dominated the top of the frequency rankings for correct vertebrate classification. Interestingly, 39/42 Saudi boys and 40/42 Saudi girls correctly classified the eel as a vertebrate.

However, Saudi children of both genders expressed significantly more alternative conceptions about vertebrates in relation to insects; many Saudi boys and girls classified the butterfly, spider, earthworm, and bee as vertebrates. In particular, significantly more girls classified butterfly, earthworm, and bee as vertebrates than did boys.

Table 2. Responses by Saudi children for identifying animals as vertebrate.

Case	4 Grade (B) **N= 42**	4 Grade (G) **N= 42**	df	*N*	χ^2	*p*
Lion	42	29	1	71	2.38	.12
snake	42	40	1	82	0.05	.83
Salmon	40	38	1	78	0.05	.82
Falcon	41	42	1	83	0.01	.91
Frog	41	37	1	78	0.21	.65
Human	41	40	1	81	0.01	.91
Butterfly	18	39	1	57	7.74	.01*

Case	4 Grade (B) **N= 42**	4 Grade (G) **N= 42**	df	*N*	χ^2	*p*
Dabb-lizard	41	40	1	81	0.01	.91
the turtle	42	38	1	80	0.20	.66
Crocodile	42	40	1	82	0.05	.83
Spider	7	33	1	40	16.90	.00*
Bat	41	42	1	83	0.01	.91
Penguin	38	41	1	79	0.11	.74
whale	40	40	1	80	0.00	1.00
Earthworms	17	38	1	55	8.02	.01*
Lizard	36	33	1	69	0.13	.72
Ostrich	42	41	1	83	0.01	.91
Dolphin	41	42	1	83	0.01	.91
Shark	41	41	1	82	0.00	1.00
Bee	18	38	1	56	7.14	.01*
Eel	39	40	1	79	0.01	.91
Total	750	812	1	1562	2.46	.12

**= significant at .05 or less*

Scrutinizing the previous table, it is possible to state that the differences between boys and girls were insignificant except in the identification of butterfly, spider and earthworms. Additionally, children's explanations and reasoning behind their selection and identification are reported along with the differences between boys and girls in the following table.

Table 3. Reasons used by Saudi children for identifying animals as vertebrate.

Category	4 Grade (B) **N= 750**	4 Grade (G) **N= 812**	df	*N*	χ^2	*p*	Examples
Not give a reason	81	148	1	229	19.60	.001*	
Structural anatomy	642	630	1	1272	0.11	.74	Their body structures are hard
External morphology	27	34	1	61	0.80	.37	Big-sized bodies compared to invertebrates

**= significant at .05 or less*

Significantly more boys classified spiders as vertebrates than did girls. In general, boys showed better knowledge of vertebrate animal classification than did girls. The critical characteristics used by the students to define vertebrates were categorized into two groups: structural anatomy and external morphology.

These categorical responses are summarized in Table 3. Children did not have a problem with the identification of mammals that have hard-structured bodies, such as lions and whale, as vertebrates. In contrast, other children explained that the spider is a vertebrate, and used the same reason.

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I know a lot about animals, I am sure the lion has backbones because the lion's body structure is hard. It is a very strong animal
(Abdulla school, B, 3)
I know the whale is a vertebrate. The whalse have backbone and body structures are hard.
(Mohmmed school, G, 5)
The Earth is a place where animals could live. Many animals live there, such as camels, sheep, wolves, goats, snakes and lizards. For example, spiders' body structures are not soft. They are vertebrates.
(Abdulla school, B, 7)

Furthermore, many participants tended to associate vertebrates with size.

Snake is very very huge, so it has backbone.
(Osman school, G, 1)
I like biology more than maths. I think an earthworm is too big. I think it is a vertebrate.
(Kiald school, B, 9)

Structural anatomy, animals having backbones, was the most popular category of reason given by Saudi children of both genders for defining vertebrates. Hence, both boys and girls showed better knowledge about anatomy. Only a few children gave external morphology as a category for defining vertebrates.

Taxonomic Animal knowledge

The most commonly selected cases of fish were salmon and shark; the entire sample (n=84; both genders) identified these two creatures. On the other hand, the most common cases of alternative conceptions were the dolphin and whale. Gender effects were not significant across all fish, with the exception of the eel, such that Saudi boys were more likely than girls to correctly classify the eel as a fish, while no girl identified it.

When dealing with amphibians, Saudi boys were again more likely to accurately and correctly classify the frog ($p<.05$), although across both genders performance was not as good in classifying amphibians as in classifying fish. A number of misclassifications were recognised: for example, 26 children in the sample believed that a turtle was an amphibian. In much the same way, 27 children incorrectly classified the crocodile, and 20 children incorrectly classified the penguin (see Table 4). When deciding on reptile species, the four most commonly chosen cases were snake, dabb-lizard, lizard, and turtle; the least commonly chosen was crocodile. Saudi girls were more likely than boys to correctly classify the crocodile as a reptile ($p<.03$). Both genders incorrectly classified earthworms as reptiles, as is seen in the cases of 10 boys and 19 girls.

When it came to classifying birds, the most commonly identified bird was the falcon for both boys and girls. However, the ostrich and penguin were classified correctly much less frequently. With regard to mammal taxonomy, the lion was the most commonly chosen for both boys and girls, with all of the participants correctly classifying the lion as a mammal; whereas bat, dolphin, human, and whale were most commonly incorrectly classified.

Importantly, although in the present research boys were found to be more likely to misclassify crocodiles as mammals ($p<.04$), they were also found to be more knowledgeable overall when it came to mammals, as in the cases of the lion ($p<.001$) and the bat ($p<.005$). When it came to classifying birds, a number of misclassifications were found, such as in the cases of the penguin and the ostrich, which were identified as mammals.

Table 4. Responses by Saudi children for identifying animals across all six taxonomic groups.

Case	4 Grade (B) **N=42**	4 Grade (G) **N=42**	df	N	χ^2	p
Fish						
Salmon	38	24	1	62	3.16	.08
Crocodile	6	13	1	19	2.58	.11
Penguin	6	9	1	15	0.60	.44
whale	26	24	1	50	0.08	.78
Dolphin	30	29	1	59	0.17	.90
Shark	37	30	1	67	0.73	.39

Case	4 Grade (B) **N=42**	4 Grade (G) **N=42**	df	N	χ^2	p
Eel	16	0	-	-	-	-
Amphibians						
Frog	32	18	1	50	3.92	.05*
Dabb-lizard	0	10	-	10	-	-
the turtle	16	10	1	26	1.39	.24
Crocodile	18	9	1	27	3.00	.08
Penguin	12	7	1	19	1.14	.25
Lizard	4	3	1	7	0.14	.71
Eel	3	12	1	15	5.40	.02*
Reptiles						
snake	39	35	1	74	0.22	.64
Dabb-lizard	26	21	1	47	0.53	.47
the turtle	14	21	1	35	1.40	.24
Crocodile	6	16	1	22	4.55	.03*
Lizard	20	21	1	41	0.02	.88
Earthworms	10	19	1	29	2.39	.10
Bird						
Falcon	40	31	1	71	1.14	.29
Butterfly	12	31	1	43	8.40	.004*
Bat	15	26	1	41	2.95	.86
Penguin	5	8	1	13	0.69	.41
Ostrich	27	26	1	53	0.02	.89
Bee	11	27	1	38	6.74	.009*
Mammal						
Lion	41	12	1	53	15.87	.001*
Human	0	0	-	-	-	-
Bat	13	2	1	15	8.07	.005*
Penguin	18	13	1	31	0.81	.37
whale	5	1	1	6	2.67	.10
Ostrich	5	6	1	11	0.09	.76
Dolphin	5	3	1	8	0.50	.48
Crocodile	9	2	1	11	4.46	.04*
Insect						
Butterfly	29	4	1	33	18.94	.001*
Spider	37	12	1	49	12.76	.001*
Earthworms	29	12	1	41	7.05	.008*
Bee	27	6	1	33	13.36	.001*

**= significant at .05 or less*

With regard to insect taxonomy, earthworms and spiders were amongst the most commonly chosen by both boys and girls. Whereas, the bee and butterfly had the lowest frequencies. This finding reveals a common over-generalisation in the case of insects, such that Saudi children tend to classify arthropods, such as spiders, within the insect category. More specifically, although boys more commonly correctly classified the butterfly ($p<.001$) and bee ($p<.001$) as insects, they incorrectly classified the spider ($p<.001$) and earthworms ($p<.008$) as insects.

Patterns of Classifications of Animals

The number of correct' justifications, 'incorrect' justifications and 'not give a reason' for all patterns across the taxonomic groups was counted, as shown in Table 5. Inspection of the table below reveals that there was a high instance of children not giving a reason to support their classifications, particularly in the insect taxonomic group.

Accordingly, children's conceptions of animal classification were limited, indicating that this task presented a

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challenge for the children. More specifically, regardless of the fact that the animal is centrally positioned in biology in Saudi science textbooks, children were found to be poor classifiers of animals.

The most accurate justification adopted by the children in defining animals was in the mammal taxonomic group (give birth to live young). Accordingly, it is suggested that Saudi children tend to assign animals a label in line with their everyday life, as seen in the case of mammals.

> *Camels give birth to a camel baby. Similarly, I think mother lion gives birth to cubs.*
> *(Kiald school, B, 14)*

It is interesting to note that none of students correctly classified the human as a mammal. This may be due to the influence of the local Saudi worldview, which is in line with Islamic principles.

> *Human is not a mammal. I do not know but the human is not a mammal. The human is not an animal.*
> *(Abdulla school, B, 14)*

Table 5. Reasons used by Saudi children for identifying animals across all six taxonomic groups.

Category	4 Grade (B)	4 Grade (G)	df	*N*	χ^2	*p*
Fish						
Not give a reason	56	81	1	137	4.56	.03*
Habitat	98	45	1	143	19.64	.001*
Locomotion	1	0	-	-	-	-
Locomotion and Habitat	1	0	-	-	-	-
Lay eggs	2	2	1	4	0.00	1.00
Give birth to live young	1	1	1	2	0.00	1.00
Amphibians						
Not give a reason	23	31	1	54	1.19	.28
Habitat	48	37	1	85	1.42	.23
Locomotion	1	1	1	2	0.00	1.00
Lay eggs	13	0	-	-	-	-
Reptiles						
Not give a reason	40	5	1	45	27.22	.001*
Habitat	3	4	1	7	0.14	.71
Locomotion	50	115	1	165	25.61	.001*
Locomotion and Habitat	2	1	1	3	0.33	.56
Lay eggs	20	6	1	26	7.54	.006*
Give birth to live young	0	2	-	-	-	-
Bird						
Not give a reason	23	16	1	39	1.26	.26
Appendages	12	2	1	14	7.14	.008*
Locomotion	49	126	1	175	33.88	.001*
Lay eggs	26	5	1	31	14.27	.00*

Category	4 Grade (B)	4 Grade (G)	df	*N*	χ^2	*p*
Mammal						
Not give a reason	6	13	1	19	2.58	.10
Habitat	10	5	1	15	1.67	.20
Lay eggs	8	20	1	28	5.14	.02*
Give birth to live young	72	1	1	73	69.06	.001*
Insect						
Not give a reason	99	14	1	113	63.94	.001*
Habitat	7	6	1	13	0.08	.78
Appendages	4	5	1	9	0.11	.74
Locomotion	8	5	1	13	0.69	.41
Small size	2	2	1	4	0.00	1.00
Behaviour	2	2	1	4	0.00	1.00

**= significant at .05 or less*

On the other hand, however, when children were defining animals, the most incorrect reasons given to justify their classification was habitat. Across the groups of animals, with the exception of the bird, this was common. This reason tended to be used for classifying those animals in the amphibian and fish taxonomic groups. For example, the children in this research commonly perceived any animal living in the sea to be a fish, and any animal living on land to be an amphibian.

> As I told you before, the salmon lives in the sea and is a fish, and the whale also lives in the sea. Both are fish.
> (Osman school, G, 4)
>
> *Okay, let me think. I think turtles are amphibians as they walk on land.*
> *(Mohmmed school, G, 9)*

Another incorrect reason used by the Saudi students when classifying the animals was locomotion; this was again the case across all animal groups with the exception of the mammal. When justifying why an animal was viewed as a bird, the most common reason provided by students was locomotion, as in appendages such as wings, or the ability to fly.

> Penguins are birds, they have wings.
> (Abdulla school, B, 8)

Such factors resulted in a number of the Saudi children making various misclassifications. As an example, almost half of the students believed bats and bees were birds, and more than half also believed that butterflies were birds.

> I like butterflies. They are cute and can fly. They are birds.
> (Osman school, G, 12)

Children named a number of different factors, including habitat and locomotion, when classifying fish and reptiles. Such use was very limited, however. Moreover, children did not seem to apply criteria while they were in the process of completing their classifications; they tended to only give one reason in support of their choices as the students quotes above indicate. With regards to classifying insects, it was common for the students to believe an insect to be small and ground-dwelling; this meant that they were more likely to incorrectly classify an earth-worm as an insect.

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An earthworm is very very small. It is an insect.

(Kiald school, B, 17)

Both genders most commonly named the habitat as the justification for defining an animal as a fish; however, boys were more likely than girls to demonstrate this particular pattern. When dealing with amphibians, Saudi boys were better able to provide scientific reasons for this classification than girls, with boys stating 'lay eggs' as a reason for their classification, while no girl able to classify it.

In contrast, locomotion was the most common rationale given for the classification of reptiles. Furthermore, despite the fact that not all reptiles lay eggs, boys in the sample were more likely to provide this as a scientific justification for reptile classification than girls ($p<.006$).

Girls were found to incorrectly classify butterflies as birds more often than boys ($p<.004$); the same pattern was observed for bees as birds ($p<.009$) (see Table 4). Saudi boys were better able to provide scientific reasons for this classification than girls, with boys stating 'lay eggs' as a reason for their classification, while no girl able to classify it. Accordingly, Saudi girls were less able to identify birds when compared with boys.

Saudi boys were better able to provide a scientific justification when defining mammals compared with girls ($p<.001$), as in the case of 'give birth to live young'. In other words, Saudi girls did not understand the concept of mammals as well as Saudi boys.

Discussion

In this research, a sample of 84 primary school students in Saudi Arabia were tested. The results of the research demonstrated that Saudi children of both genders express significant numbers of alternative conceptions about insects; many Saudi boys and girls classified butterflies, spiders, earthworms, and bee as vertebrates. Saudi children classified whales and dolphins as fish. There were many misclassifications related to the taxon amphibian; for instance, children believed that turtles, crocodiles, and penguins were amphibians. Children also misclassified earthworms as reptiles. Half of the children thought that bats, bees, and butterflies were birds; conversely, there were numerous misclassifications of birds, and of penguins and ostriches as mammals. Spiders and earthworms were commonly classified as insects by Saudi children.

The effect of gender was significant for all the taxonomic vertebrate labels, the taxa of fish, amphibians, reptiles, birds, and mammal, and the arthropod taxon insect, suggesting that Saudi boys have better knowledge about animals than girls. This finding is inconsistent with TIMSS (2015, cited by (Clerkin, Perkins & Cunningham, 2016), with respect to fourth grade girls who achieved a significantly higher score than boys in science. It is reasonable to extrapolate that Saudi girls had fewer life experiences, and therefore knew less about animals and had less pre-existing knowledge about where animals lived, behaved and so on (Allen, 2015). Compared to girls, boys expressed greater interest in wild animals and were more prepared to engage with living organisms (Prokop et al., 2008). For instance, the research in this study show that only 12/42 girls knew that lions were mammals, compared with 41/42 boys. Saudi girls were less able to identify birds when compared with boys. This finding does not align with the results of Prokop et al. (2007, 2008), who found no differences in knowledge by gender with regard to birds. However, Kubiatko et al. (2011, cited by Hummel et al., 2015) established that Slovak girls show a greater degree of knowledge about birds than boys.

Saudi children's conceptions correspond with early Piagetian studies (1929); they are simply determined by age. This research found that Saudi children generally do not have adequate forms of reasoning for biological classification. Frequently, a single attribute was used, and other attributes were ignored. More than half of the Saudi students classified the butterfly as a bird because of its mode of locomotion. The rationale is simply that butterflies have wings, so that they must be birds, even though butterflies lack feathers and a beak (Allen, 2015). Habitat and locomotion patterns are very important factors for nine-year old Saudi children when classifying animals (Cinici, 2013). Hierarchies are difficult concepts for children under five years to understand, because they have difficulties simultaneously distinguishing between subordinate and superordinate classes. This phenomenon was observed in this research, but inappropriate identification occurred across three-five years in the research of Allen (2015). For example, it is not an animal because it is a fish. However, older children consider the archetypal fish to have an elongated, streamlined body with a tail and fins (Braund, 1991; Chen & Ku, 1998; Trowbridge & Mintzes, 1985, 1988; Allen, 2015).

Driver, Leach, Scott & Wood-Robinson (1992) pointed out that many students could assign organisms to groups of their own selection but that their groups are mutually exclusive rather than hierarchical. In assigning organisms, for instance, young children will use two groups, but older children will use several groups at the same time. Students do not consistently use classification schemes similar to those used by biologists until the upper primary grades. This level of logical reasoning only emerges at around 11 years (Allen, 2015). However, the first semester Saudi science textbooks in the fourth grade (age nine years) introduce the concept of classification by consideration of the differences between living and non-living. In this grade, children also study: the general characteristics of plants and animals; the different characteristics of vertebrates and invertebrates; the classification of animals (fish, bird, insect, reptile, amphibian, and mammal); as well as the arthropod taxon insect (containing categories such as arachnids, myriapods, and crustaceans).

Prokop et al. (2007) highlight the distinction between misunderstanding and not understanding biological phenomena, and argue that below 10 years of age, children do not understand biological phenomena. Their biological knowledge is greatly affected by early experiences with other living organisms or themselves. This research's findings reinforce this assertion. Hence, there might be 'little to be gained educationally from the investment of effort required to introduce such notions at a much earlier age' (Driver, Squires, Rushworth & Wood-Robinson, 1994, p.95).

Schmidt (1996) indicated that developmental complexity suggests that some topics should be addressed with increasing difficulty, elaboration and refinement in a sequence of lessons, specifically a sequence spanning several years. In Bruner's spiral curriculum (1966), students return or revert to the same lessons repeatedly while experiencing them in progressively richer, more complex, and more inclusive forms. An example of increasing developmental complexity, focusing on a spiral curriculum and the fundamental implications of Ausubel's theory of 'progressive differentiation' is as follows (Ausubel, Novak & Hanesian, 1978, p.62): it is useful to introduce the concept of classification in the primary years with consideration of the differences between living and non-living. Then, in the middle grades, children study the general characteristics of plants and animals, and in the upper grades the focus is on comparing seed and non-seed plants, and vertebrate and invertebrate animals. By the time children enter their junior high school years they might conceivably learn about atypical plants and animals and begin a study of micro-organisms (Yen et al., 2004, 2007).

Perhaps of more significance, establishing differences and similarities is seen to improve learners' overall understanding of, and ability to use, knowledge (Marzano, Gaddy & Dean, 2000). Considering differences and similarities is essential (Gentner& Markman, 1994). Marzano et al. (2000) make the suggestion that learners need to opt to choose specific categories that are associated with one another. As an example, should learners be categorising animals and the first characteristic considers carnivores, the second could then be herbivores. Choosing a category that is otherwise unrelated, such as reptiles, would only cause confusion and therefore be unhelpful in allowing the learners to understand differences between animals. In this vein, the suggestion is made by Marzano et al. (2000) that the classification process can prove to be most useful when learners are asked to categorise animals and accordingly recategorise them as this can aid them in identifying differences between the items and provide a second opportunity to correctly classify the items if some have been missed in the first instance. As an example, following the categorisation of animals in line with food, a teacher could ask students to categorise the animals in terms of where in the world they typically come from.

Furthermore, other misclassifications were found in this research due to religious beliefs. All Saudi children interviewed did not give reasons as to why they do not consider humans to be mammals, as they thought of humans as non-animals. This finding is consistent with the work of Chen & Ku (1998), who found that Aboriginal children in Taiwan generally did not think of humans as animals. None of the second graders thought of humans as animals. These data also mirror the findings of Tema (1989), in which humans were not identified as animals by students in Botswana. The anthropocentric reasoning behind this belief was based on traditional African thinking and Christian instruction, both of which identify humans as being separate from all other animals. The findings of this research are comparable to those of Reiss (2008a), who asserted that many people found it difficult to appreciate the extent to which Darwin's claims were true at the time. Indeed, there are still many people who are unable to reconcile the theory of natural selection with their religious beliefs (Golshani, 2000; Reiss 2008a). The various societal beliefs and myths are known to have an effect on the overall understanding of Saudi children, with cognitive dimensions enriched with a number of different aspects, spanning experiential and socio-cultural. Nonetheless, traditional knowledge should not mean that scientific and evidence-based facts are not taught. Importantly, science teachers do not only have the role of ensuring that scientific concepts are taught in place of others; rather, concepts should be clarified, thus leading to the ability to differentiate between scientific and everyday concepts. Accordingly, it is important for teachers to partake in regular discourse with their students, notably through ask-

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ing and answering questions in mind of determining the links between the learner and the world of science this can position school science as being more valuable and practical. Notably, biblical content was used by Plotnick, Theodor & Holtz (2015) as a means to presenting palaeontology and evolutionary biology-related concepts, such as crown groups and stem groups. The suggestion was made by the scholars that biblical text knowledge could be utilised in mind of encouraging an interest to develop in the various approaches and concepts underpinning palaeontology and evolutionary biology. Through directing attention to text besides Genesis, these ideas could then be viewed as more palatable and of interest to those following a faith. More specifically, Kosher paleontology, as a topic of interest, could be used in discourse relating to evolution, which may be viewed as more entertaining and lighter hearted. This topic could be introduced as one aspect of adult education in line with diverse faith communities, in addition to more comprehensive public venues, including various science pubs, with time travel a subject of interest that could appeal to fans of science fiction.

Evolutionary theory is recognised as more valuable, from a scientific perspective, when seeking to present explanations concerning suffering and the struggles of the human in regard to religious theodicies. Importantly, the teaching of evolutionary biology may prove useful in answering theological questions, including that relating to suffering (Reiss, 2013). Moreover, a number of works have made the suggestion that evolution-based teaching, that is notably respectful and well-considered, can mean students are more accepting of some of the elements underpinning evolution theory (Winslow, Staver & Scharmann, 2011). As an example, Asghar (2013) has determined that, for Canadian Muslim science teachers, evolution can come down to survival of the fittest. In the work of Plotnick et al. (2015), discussions surrounding the Bible and evolution tend to centre on the somewhat minor aspect of biblical test–specifically those parts considering creation and their conflict, when taken in a literal sense, with scientific views concerning the Earth's age and history. The result is the significant wealth of writing on creationism versus evolution, with views regarding the lack of alignment between faith and evolution prominent (Reiss, 2008a; Reiss, 2008b; Hameed, 2008).

Moreover, there have been instances when explicit consideration pertaining to religion can assist science education. In this regard, there is the indication that, for natural philosophers, such as Descartes, Newton and Leibniz, the majority of work has focused on providing theological views with greater support and agreement, as shown in the work of Henry (2002), with religious influences clearly identified from the perspective of scientists. It is noted by the scholar that, overall, there is not much doubt regarding the value of religious dedication in terms of affecting and shaping early modern science. It has been recognised in the work of Asghar (2013) that Muslim philosophers and intellectuals have invested much effort towards contributing to vibrant discourses in relation to science and Islam, with such direction witnessed across many centuries and cultures. Asghar (2013) further stated that the idea of evolution, as highlighted by Islamic academics, is compatible with religious interpretations, with the interpretation and agreement of biological evolution witnessed regarding modern science. In actuality, a number of early Muslim thinkers adopted views incompatible with the theories presented by Darwin. Moreover, Asghar (2013) further recognises Muslim philosophers, such as Al-Biruni Ibn Arabi and Ibn-Khaldun, presented a number of evolutionary arguments in mind of describing the evolution of living things. In this vein, human beings were positioned as part of the animal kingdom, as presented by Ibn-Khaldun and Ibn Arabi, emphasising the relation between human beings and other animals, including monkeys (Asghar, 2013). Such writings by Islamic scholars present the implication that they believed in theistic evolution (Asghar, 2013).

In consideration to Saudi science textbooks, this work posits the view that there is a need to ensure knowledge in line with revelation, which notably supports scientific evidence, is included. As highlighted by Wardany (2000), the Qur'an provides Muslim scientists with guidance across various verses, stating that the Earth is a sphere, notably taught way before those in Europe. Furthermore, it is noted that evolution is not contested in the Qur'an, with God highlighted as having created people in 'stages' (The Quranic Arabic Corpus, 2009,71). In this vein, the word 'stages' in Arabic is 'aTwara' from the same root of evolution 'taTawwur'; thus, Earth science lessons and biology lessons should be focused on providing learners with scientific agreement in regard to evolution, with parents not able to remove their children from these teachings. Essentially, school science lessons, in part, are provided in order to give learners an insight into the key conclusions underpinning science, with the theory of evolution recognised as one of the key conclusions drawn through science (Reiss, 2013).

Moreover, in modern-day Muslim societies, it is recognised that a number of practising Muslim biologists/ scientists adopt the view of theistic evolution to bring together evolution and the religious views surrounding creation (Asghar, 2013). In this regard, Dagher & BouJaoude (2011) hold the view that deliberate engagement with socio-scientific issues and their corresponding religious perspectives are key in Muslim culture. Considering the link between religion and science is fundamental when it comes to deriving at a more in-depth understanding of science as a social enterprise and scientific content overall (Dagher & BouJaoude, 2011; Asghar, 2013).

Scientists, religious leaders and science teachers need to be more involved in the public when it comes to investigating and communicating their views on scientific knowledge and its link with religious knowledge (Dagher & BouJaoude 2011; Ferguson & Kameniar, 2014). Engagement culture as opposed to dogmatic imposition or isolation requires nurture, which further necessitates a wealth of resources and significant effort. Without such involvement, antagonistic perspectives will be recognised as most prominent and will therefore dominate any discussion, thus meaning the overall process centred on enhancing learning and teaching in science will be undermined (Dagher & BouJaoude, 2011).

Conclusions

In the present research, there is the completion of individual interviews in order to provide insight into the alternative conceptions of children regarding the taxonomic label 'vertebrate', in addition to associated vertebrate taxa, 'fish', 'amphibian', 'reptile', 'bird', and 'mammal', and the arthropod taxon 'insect'. The findings highlight that children in Saudi primary schools show a significant range of alternative conceptions regarding the categorisation of animals. Important factors in this regard, as viewed by the sample, included habitat and locomotion patterns, specifically when categorising animals. As such, the results garnered in this research present a number of critical implications for the policy makers of the Ministry of Education, in addition to those producing science textbooks. Further, developers of the Saudi curriculum need to ensure that they acknowledge the difficulties associated with introducing primary aged children to some topics, with some students needing time to develop their own conceptions.

It is apparent, when reviewing the results garnered in this research, that children's learning, in the Saudi context, is affected by their culture. Accordingly, it is true to state that Saudi children have their own complex knowledge and framework when it comes to viewing, interpreting and describing natural phenomena, with consideration to culture, everyday experience and theological knowledge. In this regard, more research needs to be completed concerning the influence of beliefs and culture in other areas, notably in line with the socio-cultural perspective. In addition, it is important to consider Saudi students' alternative conceptions in the origin of life, specifically in the Arab world, as this could result in highlighting various factors that could influence the overall understanding of the learner in relation to scientific concepts as a whole.

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Fayadh Hamed Alanazi	PhD, Assistant Professor, Jouf University, Saudi Arabia. E-mail: fayad@ju.edu.sa