

CONCEPT OF MATHEMATICAL LOGIC REASONING IN QURAN

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Abstract: *Muslims are considered a cultural group that holds the Quran as their guidance and practice regulations accordingly as a way of life. They apply mathematical knowledge to solve problems as they embrace and practice Quran's teaching. One of the mathematical cognitive domains that occurs in Quran is logical reasoning. The objective of the research is to discuss several verses in the Quran related to mathematical logic. This study uses an exploratory design on several selected verses. The results revealed that verses such as Al-Fatihah (1: 6-7), Al-Anfal (8: 29), Thaha (20:124), Az-Zukhruf (43:36), and Al-Jin (72:17) can be applied to logic reasoning using logic operation such as "not", "and", "or" as well as "implication". A statement has a True or False value but not both. An equivalent statement is proved using a truth table. By using rules of logic, the statements of the verses can be written in simple mathematical symbols besides giving precise meaning. The results of this study will allow diversification in developing high school and higher learning institution learning material related to mathematical logic reasoning and Quran.*

Keywords: *Mathematical Reasoning, Logic Operations, Al-Quran, Islamic Knowledge, Ethnomathematics.*

Introduction

Ethnomathematics is mathematics that is practiced by a cultural group that has the same or shares similar experiences, practices, and interests (D'Ambrosio, 1985). Muslims apply Islamic mathematical knowledge as they embrace, and share experiences, practices, and interest according to the teaching and regulation in the Quran founded by the belief in Allah. Recently, several research on mathematical elements, concepts and practices by certain Malay Muslim cultural groups. Their research was related to traditional arts and crafts such as motives design in textile, mat weaving, the traditional game in spinning tops, and many others (Hamidah, Muhammad Najmi & Muhamaad, 2021; Syahirah Afiqah, 2019; Nor Maizan, 2016; Nor Maizan et al., 2012; Rokiah et al., 2010).

In this research, a cultural group is referred to as Muslims who hold the Quran as their main reference and guidance in their lives. According to Wan Norliza (2011), in the history of Islam,

mathematics is an ancient knowledge that was exposed to the east and the west by the sole resource that results in it being a present from God to His servants. Mathematics also acts as an important source of knowledge for the Arabic people in terms of business, the division of wealth, and many more. Furthermore, mathematics has been utilized in business, astronomy, architecture, and family law. This knowledge was spread to the entire world throughout the Islamic glorification period between 7 to 13 AC. One of the important areas of knowledge in mathematical thinking is the philosophy of logical reasoning.

According to Bloom (2001), thinking skills can be categorized into two levels, which are low order thinking skills (LOTS) and higher order thinking skills (HOTS). Logical and scientific reasoning can be developed and mastered among students through inductive and deductive method practices (Hamidah, 2004). The Ministry of Education Malaysia (MOE) introduced the implementation of critical and creative thinking skills ((MOE, 2013). In 2014, HOTS which is known as *Kemahiran Berfikir Aras Tinggi* (KBAT) was implemented in curriculum and examination where school-based assessment was emphasized to improve students' performance (Bronkhorst et al., 2020; Hamidah et al., 2019).

In understanding of Quran's verses in relation to logic reasoning, the objectives of the research are to (1) explore logic reasoning operations applied in several verses of the Quran (2) write the selected verses in logic statement form and (3) proved an equivalent statement using a truth table and rules of logic.

Literature Review

The development of HOTS can be explored from the Quran through teaching and learning of mathematics in logical reasoning perspective.

The Holy Quran

The Quran is the words of Allah that were revealed to the last prophet, Muhammad (Peace be upon him, PBUH) through the angel Jibril and it is a miracle that proves the apostleship of the Prophet Muhammad (PBUH) and the existence of Allah SWT. The Quran is a guidance in every aspect of human life such as in the economics and ethics of trade, marriage and divorce, gender issues, inheritance and parenting. It is the main reference for Muslims which is used together with the Sunnah of the Prophet. The Quran's message is universal and eternal regardless of race, color, ethnicity, and nationality.

The Quran is the only book that everyone can use as a reference to find the truth and justice because the contents of the Quran are perfect, intact, universal, and cannot be amended. A Surah represents a chapter in the Quran. The surahs were revealed over a period of 23 years and every surah has its own name, stories, characters, and chronology of time. The total number of surahs in the Quran is 114 surah and the order of the verses in each surah is according to the provisions that Allah has set and taught by the Prophet Muhammad. The Surahs in the Quran have been classified into several characteristics categories, namely place of revelation and their length. Every surah in the Quran has its own stories, guidance, reminder, and specialty. For instance, surah An-Nisaa' narrates the way of the distribution of inheritance (Abdullah, 2012). Surah Hud verses 83 to 85 mention about measurement and weighing in business transactions. The verses are about Prophet Shuib who preached to his people to measure and weigh fairly to their customers and that they will benefit with more prosperity later.

Knowledge in the Quran covers all aspects of life including science, mathematics, agriculture, society, nation, marriage, humanities, business, and leadership. Muslim mathematical scholars in the early years make Quran their source to stimulate research and solve problems in their lives (Shaharil and Abdul Latif, 2007). Some of the knowledge of mathematics can be extracted from the Quran relating to mathematical concepts such as the regulation of the lunar calendar and the timing of the five daily prayers, the determination of the direction of the Qibla (Sheikh Husin, n.d.; Yusoff, 2018). The distribution of inheritance (efaraid, n.d.) and method of recording and paying debts. Some of the verses contain the language of mathematics related to fractions, measurements of time, distance, quantifier, logic reasoning, direction, classification, or set. Verses in the Quran which relate to numbers, connections, and shapes were explored and elaborated (Wan Norliza, 2011; Shaharil and Abdul Latif, 2007).

Some efforts are needed to clearly explain the concepts of mathematics which are implicitly embedded in the Quran. Hence, an alternative approach to redesign some of the mathematics learning materials for schools' syllabus can be considered. This research intends to lay a basic and creative approach for Muslim students in learning mathematics, have a sense of mathematics in learning Quran and encourage them to explore the knowledge in the Quran about mathematics from various angles.

Formal Mathematical Logic Reasoning

The National Council of Teachers of Mathematics and California Department of Education (NCTM, 2000; CDE, 2001) states that mathematics in high school can be described with four domains that students should learn which are number and operation, algebra, geometry and measurement, and data analysis and probability. Four cognitive domains involved in solving mathematics problems are solving routine problems, application of concepts, reasoning skills and knowledge of facts and techniques. Language of mathematics and logical reasoning which are taught in high school syllabuses are related to characteristics of higher order thinking skills (HOTS). Set Theory and Logic is included in the Malaysian high school mathematics curriculum for Form Four and Form Five (Years 16 and 17).

A mathematics concept is the general idea of mathematics. Knowing a mathematics concept means knowing the reasons behind the answers to the mathematical problem. Reid et al. (2003) identified that the conceptions of mathematics are in three hierarchies. At the narrowest level, mathematics is presented as a toolbox of individual components and procedures. At the intermediate level, the focus is on the models that are built and used to explain the actual situation and at the broadest level, mathematics is a method of life and thought. Students have a spectrum of conceptions between fragmented and cohesive. Fragmented conceptions are characterized as limited awareness of a phenomenon. Cohesive conceptions are characterized by a more inclusive, complex, and complete awareness of a phenomenon.

Some of the concepts of mathematics such as measurement and geometry can be found in the Quran. Measurement is a method to determine the value of physical quantities that consist of base quantities (Chia et al., 2019). Base quantity is a physical quantity that cannot be derived from another physical quantity. Bearing is the angle in degrees measured clockwise from north, which is a clockwise angular between two distance planes. Every Muslim is required to perform prayers five times a day and one of the pillars of prayer is facing the Qibla. The concepts of geometry, trigonometry, and spheres are also used in the calculation of the direction of the Qibla. The concept of bearing can be applied to determine the Qibla from a certain location by observing the shadow of a vertical rod on twice-yearly occasions once the sun is directly

overhead. The Qibla is also used for the burial of the dead, slaughtered animals, and sleep, which are interred facing Mecca (Britannica, 2020).

Another mathematical concept found in the Quran is logical reasoning. One of the importance of logical thinking is to develop thinking ability skills in a systematic, rational, and verifiable way between true and false arguments (Mat Rofa, 2014). Logical reasoning involves a set of rules in solving problems for certain situations. Logic has two forms, which are transitive inference and conditional reasoning. A logic that includes statements and arguments explores the applications of formal logic to mathematics. Mathematics symbols are used to simplify the statement and inference and maintain accuracy. A proposition is a declarative sentence with the truth value that can be determined as either True or False but not both. The process of making a conclusion is known as argumentation. Among logic connectives or operators are “not”, “and”, “or” and “if-then” to describe negation, conjunction, disjunction and implication. Table 1 and Table 2 show the logical truth for propositions p and q reasoning in terms of symbols. Logical equivalence refers to propositions that have the same truth values in all possible cases. For any two propositions, an implication is a statement in the form of “If p , then q ” denoted by $p \Rightarrow q$, which is read as “ p implies q ” or “ p is sufficient for q ”. P is an antecedent or hypothesis or premise while q is a consequent or conclusion. It will be true in all situations except when p is True and q is False. An implied statement is equivalent (with the symbol “ \equiv ”) to its contrapositive but not equivalent to its converse or inverse while a converse statement is equivalent to an inverse.

Table 1: Logical Truth for Negation, Conjunction, and Disjunction

Proposition	Negation (not p)	Proposition		Conjunction (p and q)	Disjunction (p or q)
p	$\sim p$	p	q	$p \wedge q$	$p \vee q$
T	F	T	T	T	T
F	T	T	F	F	T
		F	T	F	T
		F	F	F	F

Table 2: Logical Truth for the Implication of “If-Then”, Converse, Inverse, and Contrapositive

Statement		Implication	Converse	Negation		Inverse	Contrapositive
p	q	$p \Rightarrow q$	$q \Rightarrow p$	$\sim p$	$\sim q$	$\sim p \Rightarrow \sim q$	$\sim q \Rightarrow \sim p$
T	T	T	T	F	F	T	T
T	F	F	T	F	T	T	F
F	T	T	F	T	F	F	T
F	F	T	T	T	T	T	T

Hence, the objective of this research is to evaluate the application of mathematics in logical reasoning in several verses in the Quran. The significance of the research is to understand the Quran’s verses mathematically and learn in a meaningful and contextual way. This research is limited to statements and arguments in logical reasoning in terms of negation, conjunction, disjunction, and implication.

Methods

This research used an exploration or discovery approach. The exploration of words and verses that relate to logical reasoning consists of words such as “not”, “and”, “or”, “if-then” were analyzed.

Results and Discussion

The results and discussion of the Quran verses which applied concepts of mathematics in logical reasoning are explained as the following. In verses Surah Al-Fatihah (1:6-7):

(6) *Show us the straight way,*

(7) *The way of those upon whom You have bestowed Your grace, those who are not wrath and who go not astray.*

The statement from verses (6) and (7) can be broken into several propositions, such that p , q , r , and s :

p = *It is the straight way*

q = *The way of those on whom You have bestowed Your grace*

r = *The way of those who are wrath*

s = *The way of those who go astray*

The two verses can be transformed into logical equivalent statement form and the truth values are as in Table 3.

Table 3: Logical Truth for $p \equiv q$ and $p \equiv \sim\sim p$

p	q	$\sim p$	$\sim(\sim p)$
T	T	F	T
F	F	T	F

The equivalent of p and q is $p \equiv q$, that is *the straightway is equivalent to the way of those on whom You have bestowed Your grace*. If p is True, then q is True and vice versa. The negation of “*It is the straightway*”, is “*It is not the straight way*”. If p is True then $\sim p$ is False. In this case $p \equiv \sim(\sim p)$ is *the straightway is equivalent to not the way of those upon whom You have not bestowed grace*. The equivalent statement is written as $p \equiv q \equiv \sim(\sim p)$.

Two transformation rules of De Morgan’s laws are **rules of inference**. The rules contain operators of conjunction and disjunction in terms of each other via negation as in Table 4. The truth values of propositions r and s with operator “or” and “and” are as follows:

$\sim r$ = not the way of those who are wrath

$\sim s$ = not the way of those who go astray

$\sim r \wedge \sim s$ = not the way of those who are wrath and not the way of those who go astray

$r \vee s$ = way of those who are wrath or of those who go astray

$\sim (r \vee s)$ = not the way of those who are wrath or the way of those who go astray

Table 4: $\sim r \vee \sim s \equiv \sim (r \wedge s)$

r	s	$\sim r$	$\sim s$	$\sim r \wedge \sim s$	$r \vee s$	$\sim (r \wedge s)$
T	T	F	F	F	T	F
T	F	F	T	F	T	F
F	T	T	F	F	T	F
F	F	T	T	T	F	T

Combination of propositions p , q , r and s can be written as $p \equiv q \equiv \sim r \wedge \sim s \equiv \sim (r \vee s)$. Hence, verses (6) and (7) in Surah al-Fatihah are *those whom Allah guides to the straightway are those whom Allah has bestowed grace, not those who have earned anger by Allah or gone astray.*

Existing propositions and logical connectives can create new conditional statements. Two statements from Surah al-Anfal, (8:29) are chosen for an example of a conditional statement, such that:

O you who have faith! If you are wary of Allah, He shall appoint a criterion for you, and absolve you of your misdeeds, and forgive you, for Allah is the dispenser of great grace. The antecedent for f and consequent g is as follows:

Antecedent : f = *If you are wary (fear) of Allah*

Consequent : g = *He shall forgive you*

Three related conditional statements that occur are converse, inverse and contrapositive as follows:

Statement	$f \Rightarrow g$: <i>If you are wary of Allah then He shall forgive you</i>
Converse	$g \Rightarrow f$: <i>If Allah forgives you, then you are wary of Allah</i>
Inverse	$\sim f \Rightarrow \sim g$: <i>If you are not wary of Allah, then He shall not forgive you</i>
Contrapositive	$\sim g \Rightarrow \sim f$: <i>If Allah does not forgive you, then you are not wary of Allah</i>

The equivalent statement is $f \Rightarrow g \equiv \sim g \Rightarrow \sim f$ since both have the same logical truth based on Table 2. The meaning is *those who are not forgiven by Allah are those who are not wary of Allah.* The converse is equivalent to the inverse statement, $g \Rightarrow f \equiv \sim f \Rightarrow \sim g$ which conveys that *those who are not forgiven by Allah imply that they are not wary of Allah.* Proposition (1) is false since *if you are wary of Allah but He shall not forgive you.* Proposition (2) and (3) are True if the premise is False, such that *If you are not wary of Allah then He shall forgive you* while *if you are not wary of Allah then He shall not forgive you.*

Table 5: Propositions from Surah Thaha (20:124), Az-Zukhruf (43:36) and Surah Al-Jin (72:17).

Surah	Proposition $t = t_1, t_2, t_3$	Proposition
Surah Thaha (20:124) <i>But <u>whosoever</u> turns away from My Message, <u>verily</u> for him is a life narrowed down.</i>	t_1 = <i>he who turns away from My Message,</i>	x = <i>his life is narrowed down</i>
Surah Az-Zukhruf (43:36) <i>If anyone withdraws himself from the remembrance of ((Allah)) Most Gracious, we appoint for him an evil, one to be an intimate companion to him (43:36).</i>	t_2 = <i>anyone withdraws himself from the remembrance of ((Allah)) Most Gracious</i>	y = <i>Allah appoint an evil to be an intimate companion to him.</i>
Surah Al-Jin (72:17) <i>But if any turns away from the remembrance of his Lord, He will cause him to undergo a severe penalty.</i>	t_3 = <i>anyone turns away from the remembrance of his Lord,</i>	z = <i>Allah will cause him to undergo a severe penalty</i>

Another example of verses in the Quran which can be applied in relation to logical reasoning is the combination of several verses with the same meaning that can be conveyed into an implied statement to make a conclusion. For instance, the three verses from Thaha (20:124), Az-Zukhruf (43:36), and Surah Al-Jin (72:17) can be broken down into propositions t , x , y and z such as in Table 5.

All the first statements from the three verses have the same meaning as those who turn away from remembering Allah (t). The consequences of turning away from remembering Allah are described in the second statement of the three verses as their life will be narrowed down (x), an evil be their intimate companion (y) or they will undergo a severe penalty (z). The propositions can be written in terms of implication statements such that $t \Rightarrow x \vee y \vee z$. The truth values of the conditional logic statement are described in Table 6.

Table 6: Logical Truth Values for $t \Rightarrow (x \vee y \vee z)$, $t \Rightarrow \sim (x \vee y \vee z)$ and $t \Rightarrow \sim x \wedge \sim y \wedge \sim z$

t	x	y	z	$x \vee y$	$(x \vee y) \vee z$	$t \Rightarrow (x \vee y \vee z)$	$\sim (x \vee y \vee z)$	$t \Rightarrow \sim (x \vee y \vee z)$	$\sim x \wedge \sim y \wedge \sim z$	$t \Rightarrow \sim x \wedge \sim y \wedge \sim z$
T	T	T	T	T	T	T	F	F	F	F
T	T	T	F	T	T	T	F	F	F	F
T	T	F	T	T	T	T	F	F	F	F
T	T	F	F	T	T	T	F	F	F	F
T	F	T	T	T	T	T	F	F	F	F
T	F	T	F	T	T	T	F	F	F	F
T	F	F	T	F	T	T	F	F	F	F
T	F	F	F	F	F	F ⁽⁴⁾	T	T	T	T
F	T	T	T	T	T	T	F	T	F	T
F	T	T	F	T	T	T	F	T	F	T
F	T	F	T	T	T	T	F	T	F	T
F	T	F	F	T	T	T	F	T	F	T
F	F	T	T	T	T	T	F	T	F	T
F	F	T	F	T	T	T	F	T	F	T
F	F	F	T	F	T	T	F	T	F	T
F	F	F	F	F	F	T ⁽⁵⁾	F	T	T	T

For conditional statement (4), $t \Rightarrow \sim (x \vee y \vee z)$ is False since premise t is True implies to False conclusion $(x \vee y \vee z)$. The statement is read as it is false that if *he turns away from remembering Allah*, then it is false that *his life will not be narrowed down or evil is appointed to be an intimate companion to him or undergo a severe penalty*. For conditional statement (5), $\sim t \Rightarrow \sim (x \vee y \vee z)$ is True since premise t is False implies to False conclusion $(x \vee y \vee z)$. The statement is read as it is true that if *he who does not turn away from remembering Allah*, then *his life will not be narrowed down or evil is appointed to be an intimate companion to him or undergo a severe penalty*. By De Morgan's law, the equivalent statement is $t \Rightarrow \sim (x \vee y \vee z) \equiv t \Rightarrow \sim x \wedge \sim y \wedge \sim z$. This statement can be simplified as if those who remember Allah, then *his life will not be narrowed down or evil will be an intimate companion to him or undergo severe penalty*. The statement is equivalent to a simplified version as those who remember Allah then his life will prosper, no evil will be an intimate companion to him, and no severe penalty imposed on him.

Conclusions and Recommendations

The Quran is the central religious guidance of Islam revealed to Muslims. Many verses of the Quran are related to mathematical logic reasoning that can be extracted and learned. The statements with operators with negation as “not”, conjunction as “and”, disjunction as “or”, and implication as “if-then”. Certain verses may be written and read in an alternative way, a precise and simpler statement and more understandable meaning. For instance, verses 6 and 7 in surah Al-Fatihah emphasized on Muslims to beg Allah to guide them to the right path, as those whom Allah grants grace on them, turn away from being angered or astray by Allah ($\sim(r \wedge s) \equiv \sim r \vee \sim s$). In verse 8 of Surah Al-Anfal (8:29), the message is if a Muslim is wary of Allah, then Allah will forgive him. That is, those who are not forgiven by Allah, are those not wary or fearful of Allah ($f \Rightarrow g \equiv \sim g \Rightarrow \sim f$). For verses Surah Thaha (20:124), Surah Az-Zukhruf (43:36), and Surah Al-Jin (72:17) the summarization and implication of the meanings are if a Muslim remembers Allah, then his life will be prosperous, `evil will be near to him and no severe penalty imposed on him ($t \Rightarrow \sim(x \vee y \vee z) \equiv \sim x \wedge \sim y \wedge \sim z$).

The knowledge of mathematics extracted from the Quran can be categorized into domains of mathematics based on the school syllabus to develop the learning materials which comply with the curriculum. The teaching of logical reasoning which has been implemented in the Malaysian curriculum can improve students' ability in HOTS since logic is the basis of mathematics (Hamidah et al., 2019). From the discussion of the verses, teaching and learning mathematics can be done in contextual approaches through understanding the contents of the Quran. For further research, it is recommended to explore other Quran's verses that contain concepts of logical reasoning such as transition, deduction, induction, abduction, and proving (Mat Rofa, 2014). Qualitative research can also be conducted by interviewing content experts to get a deeper understanding of logical reasoning from the Quran.

The process of emphasizing Islamic values in teaching and learning mathematics can be placed in schools, especially for the Islamic stream. Hence, educators can use the outcome of the research as an alternative in developing learning material to broaden students' mathematical knowledge with a deep understanding of the Quran. In conclusion, the Quran is not only a life's guidance revealed by Allah but it is a part of the academic textbooks. The Quran can also be used as reference material for discovering mathematics and makes the learning of mathematics meaningful by understanding it thoroughly.

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