An Introduction to Logic and Critical Thinking

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***Abstract:-*Our main objective in this paper is to improve our logical thinking skills and to expose us to basic pitfalls in human reasoning. The most important critical thinking skill is the skill of making judgments, not spontaneous judgment that occurs in the twinkle of an eye, but those that require careful and deliberate reasoning. The purpose of studying Logic and Philosophy at this level of academic tutelage is to facilitate students' thinking ability in tackling herculean tasks, addressing recalcitrant and intractable issues and been able to easily confront problem areas in their respective field of study. Good thinking therefore, is a necessary factor to securing excellent academic performance. Logic provides rigorous ground for whatsoever belief, position or opinion we are holding. It enables us to develop critical attitude in us to query and investigate some assumptions and presuppositions in our various disciplines that we often take for granted. It also enables us to identify common errors (fallacies) in human reasoning. As matter of fact, we need logic for good business plan and to manage personal, corporate or public affairs.**

***Keywords:* Logic, Reasoning, Arguments, Reasoning, and Fallacies**

INTRODUCTION

Nature and Meaning of Logic

Reasoning is a kind of thinking in which problems are solved, inferences take place, and conclusions are drawn. All reasoning involves thinking but all thinking does not necessarily imply reasoning. What then is reasoning and how can we identify good reasoning? Reasoning could be defined as a systematized or organized chain-process of thought. Reasoning is a transition in thought, where some beliefs (or thoughts) provide the ground or reason for coming to another. High quality of reasoning is called logical reasoning or critical thinking. Logical reasoning can be learned or improved. It is not a question whether you are naturally good at it or you're not. Rather, every student or learner has the ability to reason well, and everyone is capable of improvement. The usefulness of logical reasoning as a means to making more effective decisions about your own life lies in decision about what to believe, accept and decision about what to do and when to do it.

a. What is Logic?

What is logic and what is its subject matter? Logic is the study of the principles and methods of correct reasoning. Put more technically, it is the study of principles and methods of valid inference. (Adeniyi O.R & Ayedero T.M, 2016:2). It is not, as is it is often supposed that, logic is the science of thinking as such. for thinking can take many forms, such as remembering, intuiting, imagining, and freely associating, which however interesting in themselves, are of little consequence to the logician. Our concern is with reasoning only. It is true that all reasoning involves thinking, but all thinking is not reasoning. Some thinking does not involve reasoning.

Logic simply put is a method and technique of distinguishing between valid, correct, sound, and good reasoning (arguments) from invalid, incorrect, unsound and bad reasoning (arguments). Logic is the general science of argument (Robert J.F & Armstrong W.S 2005, 2). It is chiefly concerned with arguments. In logic, the term argument denotes any group of propositions consisting of conclusion i.e (the proposition the argument is alleged to establish) and one or more premise(s) (propositions offered as evidences for the conclusion). An argument therefore is made up of premises (evidences) and a conclusion. 'Premises' and 'Conclusion' constitute the structure of an argument. The propositions which are affirmed as providing support or reasons for the conclusion are the premises of an argument. The concern of logic is not actual process of reasoning but rather the correctness and soundness of products of reasoning. It should be noted that, philosophical reasoning is argumentative by nature. *Argument therefore involves chain of reasoning where by certain inferences are made on the basis of others*. What then is an inference?

b. Inference

An inference is a process by which one proposition is arrived and affirmed on the basis of one or more other propositions accepted as the initial point of the process, and the end point comes with the drawing of the conclusion from given set of premises (Adeniyi 2004,139). It has also been argued in some quarters that inferences are statements we make about the unknown using the known as their foundation (Ucheaga D.N 1992, 35). Inference is endpoint of reasoning which may be characterized as either inductive or deductive reasoning. Let consider the example below:

All Ravens observed in Africa are black

All Ravens observed on Asia are black

All Ravens observed in South America are black

All eagles observed in United State are black

Inference. *Therefore, all Ravens are black*

The inference drawn is the conclusion arrived at from the premises offered to support the conclusion.

c. Proposition

A proposition is a statement of fact which can be appraised as either true or false. Propositions are expressed in sentences, but the reverse is not the case of all sentences. Logicians are not interested in all kinds of sentences. There is the need to distinguish those which express propositions and those which do not. Let us briefly consider the following sentences;

i. Martins is a female lecturer
ii. Water boils at 100^{o}c
iii. The H.O.D is not on seat
iv. Shut the door behind you!
v. Get out of my office!

Examples (i-ii) are propositional sentences because they can be true or false. On the contrary, examples (iv-v) are ordinary command sentences which cannot be said to be true or false. At most, they can either be said to be grammatical or ungrammatical whereas sentences that express proposition are either true or false. Sentences that express proposition are called statements (Adeniyi 2004).

d. Arguments

Literarily speaking, the word "argument" may suggest quarrel or squabbles, or conversational disagreement. But this is just a layman understanding of an argument and a broader sense of usage. Technically, in logic, argument means giving reasons for or against some claims. For purpose of logical analysis, the components of an argument (premises and conclusion) are usually written in a sequence whose last member is the conclusion. For the purpose of clarity, we shall briefly consider some arguments and identify their premises and conclusions.

Example i

Premise1= All men are mortal

Premise2= All mortal are predetermined to die

Premise3= Socrates is mortal

Conclusion= Socrates is predetermined to die

The argument above comprises of four propositions. The first three propositions are premises which provide 'evidence' for the alleged claim the last proposition that is, the conclusion of the argument.

Example ii

Premise1= All African countries are going through economic recession

Premise2= Nigeria is an African Country

Conclusion= Nigeria is going through economic recession

Note that, arguments are not always pattern in line with the pattern of our two examples above. In some cases, the conclusion may be sandwiched within the body of the argument or it may even start with the argument.

Example iii

Premise1= All teenagers are students

Conclusion= and all my children are students

Premise2= since all children teenagers

In the above arguments, to identify the structure, that is, the premises and the conclusion, attention has to be paid to contexts. We need to discover the issue at stake. However, the structure of many arguments can be identified by the provision of certain indicators we may call premises and conclusion indicators.

e. Conclusion and Premise Indicators

To carry out logicians' task of distinguishing good from bad arguments, we must be able to recognize arguments when they occur and must be able to identify the premises and the conclusions of those arguments. When we confront a passage that we understand to be an argument, how can we tell what its conclusion is, and what are its premises? We have already seen that an argument can be stated with its conclusion first, last or sandwiched between its premises. Hence the conclusion of an argument cannot be identified in terms of its position in the formulation of the argument. How, then, can it be recognized?. Some words or phrases typically serve to introduce the conclusion of an argument. Such expressions are referred to as *"conclusion-indicators"*. The presence of any of them often, signal that what follows is the conclusion of an argument. (Copi Irving & Cohen Carl 2001). Here are partial list of conclusion indicators:

> Therefore, Hence, And, So, Thus, Accordingly, It follows that, Proves that, Consequently, As a result, For these reasons, Which entails, Which implies, which allow us to infer that, In consequence Other words or phrases typically serve to mark the premises of an argument. Such expressions are called "*premise indicators*". The presence of any of them often signals that what follows is a premise of an argument. Here is a partial list of premise indicators: Since, Because, For, As, As indicated by, The reason is this, For the reason that, More also (See Adeniyi & Ayedero 2016).
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> Once an argument has been recognized, the words and phrases listed above help to identify its premises and conclusions.

Types of Logic

Traditionally, reasoning in logic could be deductive (Formal Logic) or inductive (Informal Logic). Formal logic is logic of *'PURE FORM'* while inductive logic or (Informal logic) is logic of *'CONTENT'*. It is true that every argument involves the claim that its premises provide some grounds for the truth of its conclusion, but only a deductive argument involves the claim that its premises provide *conclusive* grounds for its conclusion (Copi Irving & Cohen Carl 2001, 61). What exactly we are saying when we claim that deductive logic is a logic of 'pur e form' is all about the relation that exists between the set of propositions that make up an argument. The arrangement of the proposition is such that we can infer that one follows from others. Therefore, formal or deductive reasoning (logic) can be said to be *Valid or Invalid*.

i. Inductive Logic

Inductive logic is an empirical science that concerns itself with what people do or say in their daily activities. It is the logic of content rather than of form (Nwigwe B.E 1992, 4). The most important thing to stress is that informal logic is a supremely practical enterprise. It is directly concerned with ordinary human activities as defending position, citing observed cases or event in making general statements, attacking unsupported claims, and detecting misleading examples and bad analogies or arguments.

The concept of validity or invalidity is not applicable to inductive logic. Rather, inductive logic can be said to be sound or unsound. The premises of an inductive argument may not provide conclusive support for the conclusion. Hence, the conclusion of an inductive argument only be said to be probable.

ii. Deductive Logic

In a deductive (formal argument), the premises give absolutely conclusive grounds for the conclusion. "Valid" and "Invalid" are used in place of "Correct" and "Incorrect" to characterized deductive arguments. A deductive is valid when its premises and conclusion are so related that it is absolutely impossible for the premises to be true unless the conclusion is true also. (Copi Irving 2001,3). If a deductive argument is valid and, if all the premises of that argument are true, then the conclusion must also be true. There can never be in a valid deductive argument with all true premises and at the same time a false conclusion. (Adeniyi, 2004, 26). Thus, the term "Valid" and "Invalid" is not applicable to inductive arguments. Inductive arguments differ among themselves in the degree of likelihood or probability that their premises conferred upon their conclusions.

a. Truth and Validity

Propositions or statements can either be true or false. We cannot speak of arguments as being true or false. Arguments are not properly characterized as being either true or false but rather as valid or invalid. This distinction however, does not mean there are no connections between validity and invalidity or truth and falsity of its premises and conclusion. While the notion of truth and falsity, validity and invalidity are quite distinct, there is an important relation holding between them in deductive argument. The fact is that, this connection may not be a simple one. For instance, a valid argument may contain only true propositions. A good example is this argument:

All cats are mammals

All mammals have lungs

Therefore, all cats have lungs

Both the premises and conclusion of this argument are true proposition, but it is equally possible for a valid argument to contain false propositions exclusively. For example;

All boys are male students

All male students have wings

Hence, all male-students have wings

This is a valid argument, for if its premises were true, its conclusion would have to be true also, even though they are actually false. Our two examples have shown that the validity of an argument does not guarantee the truth of its component propositions. An argument may be valid or invalid even if all its compound propositions are either true or false. An argument is only invalid if its premises are true and its conclusion is false.

Logical Symbols

Although traditional categorical logic can be used to represent and assess many of our most common patterns of reasoning, modern logicians have developed much more comprehensive and powerful systems for expressing rational thought. These newer logical languages are often called "symbolic logic," since they employ special symbols to represent clearly even highly complex logical relationships.

In order to avoid the vagueness of ordinary language, logicians reduced their arguments to their forms by the use of specialized logical symbols. This reduction becomes possible because the concern of symbolic logic seems to be the syntactic rather than semantic relations between propositions. More also, formal logicians are more concerned with the forms of an argument rather than their contents (S.O Dada 2001). A further point of logicians' special symbol is the aid they give in the actual use and manipulation of statements and arguments. Drawing of inferences and the appraisal of arguments is greatly facilitated by the adoption of special logical notation. The importance of symbolic logic when will consider Alfred North Whitehead claim is that:

> … by the aid of symbolism, we can make transition in reasoning almost mechanically by the eye, which, otherwise would call into play the higher faculties of the brain. (Alfred N.W 1911, 61

Commenting or Alfred N.W claim, Copi Irving argues that, logic is not concerned with developing our powers of thought but with developing techniques that permits us to accomplish some task with outmost ease.

b. Propositional Variables

Propositional variables are lower case alphabetical letters ranging from *p to z* which are used to represent propositions. There are ordinary letters for which any statement may be represented. Propositional variable could be employed to represent either simple or compound statements. It is simple when the statements lack other component parts to serve its meaning. Simple statements are also referred to as atomic statements (SO. Dada 2001, 153). or example, "Martins is a lecturer" is an example of simple statement. Compound statements on the other hand, have other component parts to serve its meaning or to provide additional information. Example, the statement, Martins is a lecturer and Martins is a student.

Let "r" represent Martins is a Lecturer and "p" represent Martins is a student. Where 'r' and 'p' are variables and can stand for any object. The statement Martins is a lecturer and Martins is a student becomes (r.p). Here, 'and' represented with a 'dot' is a logical connectives. There are other logical connectives as will be discovered below.

c. Logical Connectives

Logical connectives are statements connectives as demonstrated above by means of which compound and complex statements are derivable from simple ones. They are also referred to as logical constant or logical operators since their meaning and values are fixed. They are also called truth functional connectives since they enable us to determine the truth value of the statements resulting from their use.

The table below shows us the five main logical connectives.

S/N	NAMES	SYMBOL
1	Conjunction	•
2	Disjunction	V
3	Negation	~
4	If Then…	⊃
5	If and only If	≡

i. Conjunction

The truth-value of a conjunction is determined by the truth values of its conjuncts. Given any statements 'p' and 'q' (where 'p' and 'q' are statement variables), there are just four possible sets of truth-values they can have, and in every case the truth value of their conjunction is uniquely determined. The four possible sets of truth value can be displayed by means of truth table as follows:

p	q	**p•q**
T	T	T
T	F	F
F	T	F
F	F	F

***Given any two statements 'p' and 'q' then (p•q) is true if, both 'p' and 'q' are true. In all other cases, (p•q) is false. Therefore, a conjunction can only be TRUE under only one circumstance, that is, when the two conjuncts are TRUE*. In other circumstances, a conjunction is false (Adeniyi 2004, 32) .**

ii. Disjunction

Disjunction is formed of two compound statements by inserting the word 'or' in them. In other words, two statements are combined disjunctively by inserting the word "or" between them. The two component statements so combined are called disjuncts. The statements either Martins is a Lecturer or Martins is a student may be conjoined to formed a disjunctive statement. The word "disjunct" may be used either inclusively or exclusively. An inclusive disjunct is true in case one or the other or both disjuncts are true; only when both disjuncts are false is when exclusive disjunction is false (Copi Irving & Cohen Carl 2001, 326). We interpret the inclusive disjunction of two statements as an assertion that at least one of statement is true, and we interpret their exclusive disjunction as an assertion that at least one of the statements is true but not both are true.

p	q	Pvq
T	T	T
T	F	T
F	T	T
F	F	F

Given any statement 'p' and 'q', then any statement "pvq" is true if and only, at least one (and perhaps both) of its disjuncts are true. A disjunct is false only under one circumstance, that is when the two disjuncts are false together.

iii. Negation

The (negation or the contradictory or the denial) of a statement in English is often formed by the inserting "not" in the original statement. Alternatively, one can express the negation of a statement in English by prefixing to it the phrase "*it is not the case*" or "*it is false that*" ot is customary to use the symbol "~" curl or "tilde". Take for instance," it is not the case that all men are mortal" or "it is false that Martins is a student" are both negative statements. The negation of any true statement is false and the nation of any false statement is true. This fact can be clearly and perfectly represented by truth table below

P	~p
T	F
F	T

The truth table may be regarded as the definition of the negation symbol "~". Given any statement 'p' is true, '~p' is false and if 'p' is false, '~p' is true.

iv. Conditional

A statement compounded by "if then…" is known as a conditional or hypothentical statement. The first of its two component statements is called the antecedent (protasis or hypothesis). The second component placed after "then" is called the consequent (or apodesis). In any conditional statement with true antecedent and false consequent is false. In all other three combinations of truth-values, the conditional is true. Therefore, all truth-functional conditional with false antecedents and all with true consequents are true. Only those are false which have true antecedents and false consequents. Symbolically, the truth-functional conditional is rendered by the connectives "⊃" and its truth is defined by the following table:

p	Q	p⊃q
T	T	T
T	F	F
F	T	T
F	F	T

Given any statement 'p' and 'q' then any statement (p⊃q) is true EXCEPT when 'p' is true and 'q' is false. The only condition or circumstance a conditional statement is false is only when the antecedent is true and the consequence is false. In all other circumstances, it is true.

A conditional statement according to Copi asserts that in any case which is its antecedent is true, its consequent is true. It does not assert that its antecedent is true, but rather that, if its antecedent is true, its consequent is true also. It does not as well assert that its consequent is true, but only that it's consequent is true if its antecedent is true (Copi Irving & Cohen C 2001, 356). A conditional statement is true in all cases except when the antecedent is true and the consequent is false. By implication, all truth functional conditionals with false antecedent and all with true consequents are true.

v. Bi Conditional

We have a bi-conditional statement when two statements (forming one compound statement) are said to be materially equivalent. They are materially equivalent when they have the same truth-value. Then, the two statements materially imply each other. We introduce the three-bar or taldes "≡" to symbolize material equivalence and it may be read "if and only if". The bi-conditional "p≡q" is defined by the following truth-table:

p	Q	p≡q
T	T	T
T	F	F
F	T	F
F	F	T

Given any statement 'p' and 'q', p≡q is true if and only if bothe 'p' and 'q' are true or both are false, that is, when they both have the same truth-value.

Nine Rules of Inference

There are basic formal rules of establishing the validity of logical reasoning most especially when it pertain formal arguments. These rules specify the methods of deducing inferences and how to arrive validly at a conclusion. In this respect, Copi outlined *Nineteen Rules of Inference* (Copi & Cohen 2001, 357). However, considering the scope of this study, we shall limit ourselves to the first *Nine Rules of Inference* in this paper.

1. The first rule ***Modus Ponens (M.P)*** states that the truth of the antecedent of conditional statements implies the truth of its consequent. In other words, given that (p⊃q), the moment we have p, necessarily q must follow.

   Modus Ponens (M.P)

   P⊃Q

   P

   ∴ Q

2. The second rule of inference ***Modus Tollens (M.T)*** states that the negation of the consequent of a conditional statement implies the negation of its antecedent.

   Modus Tollens (M.T)

   P⊃Q

   ~Q

∴ ~P

The third rule of inference which is ***Hypothetical Syllogism (H.S)*** states that, if there are two conditional statements and the consequent of one is the antecedent of the other, then the antecedent of the first implies the consequent of the second.

Hypothetical Syllogism (H.S)

P⊃Q

Q⊃R

∴ P⊃Q

The fourth rule of inference ***Disjunctive Syllogism (D.S)*** states that when we have a disjunction of two statements, the denial of the first disjunct implies the truth of the second disjuncts.

Disjunctive Syllogism (D.S)

P v Q

~Q

∴ P

3. ***Constructive Dilemma (C.D)*** which is the fifth rule of inference states that, if we have a conjunction of two

conditional statements, the disjunction of their antecedents also implies the disjunction of their consequents.

Constructive Dilemma (C.D)

(P⊃ Q) • (R⊃ S)

P v R

. ˙ . Q v S

4. The sixth rule of inference, ***Absorption (ABS.)*** states that in conditional statements, the antecedent implies the conjunction of both the antecedent and the consequent.

Absorption (Abs.)

P⊃ Q

. ˙ . P⊃ (P•Q)

5. According to the seventh rule of inference ***Simplification (Simp.)***, in a truth functional conjunction, the truth of the first conjunct is deducible from the conjunction of the two conjuncts

Simplification (Simp.)

P • Q

. ˙ . P

6. According to the eighth rule ***Conjunction (Conj.)***, given the truth of two compound statements, their conjunction could therefore be logically inferable from the set of atomic statements

Conjunction (Conj.)

P

Q

. ˙ . P.Q

7. ***Addition (Add.)*** The ninth rule of inference states that, when you have a simple statement, you may add another simple statement through conjunction to make it *conjunctive* statement provided it will give you desired result.

P

. ˙ . P • Q

Application of the Nine Rules of Inference

First we have to make it a practice to begin our proof with the conclusion of an argument and work "backward" to the premises. This is to say that we need always to first inspect our conclusion and ask what type of statement it is; and how does the conclusion appear in the premises. Second we try to apply certain "*rules of thumb*" to premises. When we do this, the construction of proofs will become relatively easy.

Examples

1. (A.B) ⊃C

∴ (A•B) ⊃ [(A•B) •C = **Absorption Rule 6 (Abs.)**

2. (DvE) • (FvG)

∴ DvE = **Simplification Rule7(Simp.)**

3. H⊃ I

∴ (H⊃ I) v R = **Addition Rule 9 (Add.)**

4. (A⊃ B) ⊃ (CvD)

A⊃ B

∴ CvD = **Modus Ponens Rule 1 (M.P)**

5. (J⊃ K) • (K⊃ L)

L⊃ M

∴ [(J⊃ K) • (K⊃ L)] • (L⊃ M)] =**Conjunction Rule 8 (Conj.)**

Exercises

For each of the following elementary valid arguments state the rule of inference by which its conclusion follows from its premise(s).

1. (XvY) ⊃ ~ (Z•~A)
3. (W•~X) ≡ (Y⊃Z)

~~ (Z•~A) ∴ [(w•~x) ≡ (Y⊃Z)]v(X≡~Z)

∴ ~(XvY)

2. [N⊃ (O•P)] • [Q⊃ (O•R)] 4. [(O⊃P) ⊃Q] ⊃ ~ (CvD)

NvQ
(CvD) ⊃ [(O⊃P) ⊃Q]

∴ (O•P)v(O•R)
∴ (CvD) ⊃ ~ (CvD)

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