Research Article

Hosted & indexed by Sabinet

The Dyke
www.thedyke.msu.ac.zw

ISSN 1815-9036 (Print)
ISSN 2790-9036 (Online)

A synoptic history of 'the *scientific method*' with reflections on the scientific terms that emerged from the Greek, Arabic and Latin languages and pointers for *Chi*Shona.

Farai Daniel Madzimbamuto[a]
[a]University of Zimbabwe

ARTICLE HISTORY

Published online, 2023

Abstract (*Rupfupi*)

The 'scientific method' as a system of knowledge creation and organisation emerged principally in the last thousand years, although its history can be traced back to the ancient Greeks. It is a formal process which starts with formulating a hypothesis, then developing a method of testing the hypothesis, followed by observation (data collecting) and analysis, ending in a conclusion which should be a starting point for new hypotheses. Scientific terms often represent a concentration of ideas or exactness of expression in a discipline. Scientific terminology in European languages uses Greek and Latin roots, even today, because these were the languages of learning in Europe at the time when science experienced its greatest development. Arabic was a major source language for scientific and mathematical terms, bequeathing to English 'chemistry' and 'algebra' among others, while itself borrowed from Greek. Going back to the beginning of the scientific concepts is an established practice in science for exploring words, their old uses and potential new uses. A term, such as 'mathematics' or 'atom' today stands at some distance from what it meant even a hundred years ago. There is room therefore for building words and terminology from the ground up, or inside out, from the early meaning of the source words. This can give a different perspective and useful insight for how a language such as *Chi*Shona can build scientific words. The history of the 'scientific method' is illustrative of the process of how words in common use became the essential building blocks of vocabulary of science. The essay focuses on the essential foundation concepts and words of science and how many of these are already present in *Chi*Shona and can be mobilised for the scientific discourse. A glossary and appendix are provided in the supplementary material.

KEYWORDS (*Mazwi ekunanga*): scientific method; theory of science knowledge; scientific argument; history of science; scientific experiment; science terms in *Chi*Shona;

CONTACT : Farai D Madzimbamuto faraitose@hotmail.com

Introduction (*Musumo*)

The 'scientific method' is a system of thinking about, and organising, knowledge that is based on a structured method of acquiring knowledge by first developing a hypothesis, and then testing it. It experienced rapid development in Europe in the 1700s but particularly traces its history back to the ancient Greek, and Mediterranean and Near East cultures in general (Vignais & Vignais, 2010 pp. 7-47)

The 'scientific method' is a system of knowledge creation and organisation. It is a formal process which starts with formulating a hypothesis, then developing a method of testing the hypothesis, followed by observation (data collecting) and analysis, ending in a conclusion which should be a starting point for new hypotheses. Scientific terms often represent a concentration of ideas or exactness of expression embodying the knowledge of that discipline.

What follows is a synopsis of the development of the scientific method of enquiry while exploring the development of the terminology that emerged. By going back through the narrative from the ancient Greeks, the aim has been to focus on the technical words developed as many of these, or ideas, are still of the sources of science vocabulary today.

Nature (*Usikwa*)

The path to modern science is believed to begin with the Greeks of lonia on the coast of Anatolia in what is now modern-day Turkey. A movement which sought to abandon explanations of events in nature, and in peoples' lives through religion and custom emerged. Individuals and schools sprung up in the Greek world whose drive was to 'enquire' or seek knowledge about nature (Gk: physis; Sh: *usikwa*) and discuss, reason or give account (Gk: logos) (Lloyd, 1970; Curd, 2021).

The early Greek thinkers are important in the origin (Sh: *ugo*) of science because they laid down the first building blocks of ***enquiry*** (Gk: historia; Sh: *tsvakurudzo*), ***contemplation*** (Gk: theoria; Sh: *kufunga, kupanga*) and the explaining of *nature* (Gk: physic; Sh: *usikwa*) in Western thought (Hall, pp. 1-29, 2014; Lloyd, 1970). 'Logos' originally was used in the sense of 'word, voice, pronouncement' (Sh: *izwi, mazwi, mashoko, zvarehwa*), and came to mean 'reasoning' or 'systematic account' (Sh: *rondedzero*) as when used by Heraclitus, and much later in time

Aristotle used the word in the sense of 'reasoned discourse' (Sh: *nhaurirano*) (Curd, 2021).

The discussion about the natural world, 'physiologos', (Sh: *nhaurirano dzezveusikwa, kurukurano dzeusikwa*) was central to constructing rational models of the world and what nature was made of. The Greeks had no general word for 'matter'. Initially, the early philosophers used the terms 'first principle' (Gk: arche), 'the infinite/indefinite' (Gk: opeiron; Sh: *usangagumi, kusapera, ruenderera*), 'rhizomata' meaning 'roots' (Sh: *mudzi)*, as in 'origin' (Sh: *vambiso, vambiro, muvambo*) of something (Kraut, 2017).

Later, the Greek word 'stoicheion' was used, meaning 'a letter (i.e., element) of the alphabet'. Aristotle used the word 'hyle', meaning 'wood/timber' to indicate 'whatever can be shaped into something or given a form' (Sh: *munyakwe*), or the material from which things are made.

Latin translators in medieval Europe translating from Aristotle chose the Latin word 'materea' over more specific words to carry the sense of 'substance' rather than wood/timber (Lloyd, 1992). A *Chi*Shona word for 'element' could be '*vambo*'.

How knowledge (Gk: episteme; Sh: *ruzivo*) of nature is acquired was an important 'physiologos' or discussion about nature, (Sh: *nhaurirano dzeusikwa*) (Back, 2006; Cleary, 1985). Was nature to be understood from 'observation' (Sh: *matariro, kutarira, kuona*) or from thinking and reasoning about it? When nature is experienced through the senses (Sh: *manzwisa*), it is clear there are many instances of 'misperception' or even discerption. A stick will appear bent when dipped in water, for example.

Parmenides (515-450, BCE) argued for rigorous use of reasoning (Sh: *mafungiro*) and logic (Sh: *kutsikanidza pfungwa*) as the only 'true' way regardless of what conclusions this might lead to? On the other hand, observation and record keeping in astronomical studies and Hippocratic medicine had made it possible to develop understanding through analysis (Sh: *ongororo, penenguro*) of the observed material leading to rational predictions as demonstrated with the solar eclipse of 585BCE which Thales predicted.

The Hippocratic corpus that emerged from documented medical case notes and anatomical descriptions allowed physicians to recognize disease patterns and coin terms still in use today such as symptom (Sh*: chiratidzo),* diagnosis (Sh: *durautenda*), prognosis (*dudziro*).

Reasoning (Mafungiro)

The early Greek thinkers or natural philosophers up to Socrates are referred to as pre-Socratic philosophers (Curd, 2021). Socrates major contribution was to take the rationality of the outward gazing natural philosophers and turned it inwards on personal life (Sh: *magariro, ugari, uraramo*) and society (Sh: *ugari muruzhinji*). Aristotle (384-322 BCE) was the first to write down a formal structure of thinking for use when looking at natural phenomena, natural philosophy (Sh: *nyarudezivo reusikwa*) in the 'Organon' (Aristotle). Aristotle outlined a process for describing what reasoning was, and how to structure an enquiry into a problem or know what the right question to ask was (Shields, 2020). In this way he developed further the distinction between commonly held beliefs and 'systematic knowledge' (episteme). Commonly held beliefs are explanations based on tradition, religion, history, superstition and others which may not be rational, but above all are not verifiable. Systematic knowledge (Sh: *ruzivotsetse, murongwazivo*) is what later came to be translated into Latin as 'science' (Latin for 'knowledge'). Knowledge, he argued, began with an observation (Sh: *chaonwa*), then through abstraction (Sh: *susunho*), to conclusions (Sh: *gumisiro*) from which principles or axioms (Sh: *revo, muko*) were drawn.

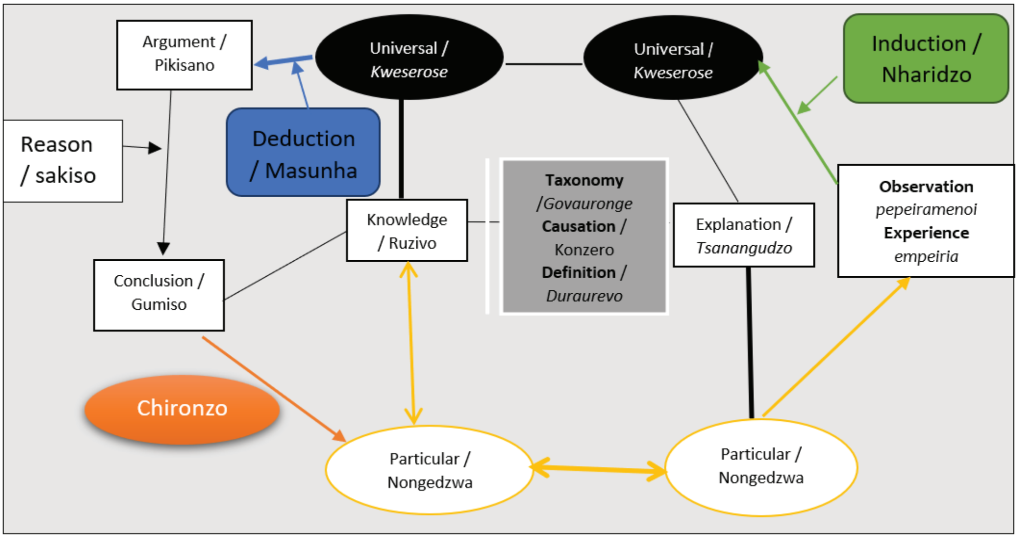

Figure 1 (Chiumbiko): Structure of Aristotle's explanation of the how we (should) acquire knowledge.

According to Aristotle, an argument (Sh: *pikisano*), as in making a case for something, consisted of two premises (Sh: *pikiso*) and conclusion (Sh: *gumisiro*). Reason is the link between the premises and the conclusion, and reasoning is the search for such a link, and it must prove the conclusion. He argued that, since we are born without knowledge, the so-called *tabula rasa* (Sh: *saroziva*), we first must experience (Sh: *rushwiro*) reality (Sh: *kuvapo, uvapo, hupo*) through the senses (observation, experience). This gives information about the world. Then follows a process of accumulating experiences and recognizing patterns (Sh: *cherechedza misambo*) while sifting through this information to achieve a certain consciousness which leads to understanding (Sh: *rugutsikano*).

However, this understanding will be poor or insufficient unless a systematic approach of logical thinking is used. This logical system, which he elaborated on, is used to abstract (Sh: *kususunha*) what is essential, the essence of something, and lead to statements or premises which are true or correct about the question. So, although he was aware of knowledge production through induction (Sh: *nharidzo*) and deduction (Sh: *masunho*), his emphasis was in deduction, and theoretical reasoning (Sh: *chironzo*) (Figure 1).

For the Greek philosophers of Aristotle's time, real 'knowledge' had to be true everywhere, forever. For example, from experience, it was known that the horizon was curved, a distant object appeared top first, and different star constellations were visible in the night sky depending on geographical location and other known observations of the time: all of which suggested a curvature of the earth. From this it could be concluded that the earth was a sphere (Sh: *hurungo*), and that fact was universal (Sh: *kweserose)*, eternal truth (Sh: *idi narini*). Knowledge about this could be used deductively to construct theoretical arguments (Sh: *chironzo*) about the seasons, weather, geography, biology, mathematical measurements of the earth and many other fields. These universal principles (Sh: *muko, revo*) then constituted real knowledge and they can be used to systematically structure the observations and abstractions to create a knowledge discipline (Sh: *davi rezivo*).

In this way, he also defined an argument (Sh: *pikisano*) which moved from a general premise (Sh: *pikiso*) to specific conclusions (Sh: *magumo*). Some domains of knowledge were found to use deductive reasoning predominantly, for example mathematics. In a deductive argument, if the premises can be shown to be true, then the conclusions are going to be inescapably true as well. This was important to early philosophers, the demonstration of a premise to be true, and the construction of a valid argument (Sh: *pikisano ine ruramo*), became important exercises. The explanatory process was, therefore, largely based on theoretical speculations with little attempt at investigative study (Lloyd, 1964; Mayo, 2019).

Once knowledge could be shown to be true and universal, it also became important to explore what the purpose of 'creating' such knowledge was. Aristotle argued that the purpose was to explain the causes (Sh: *sakiso*) that related different things to each other and to change (Sh: *sanduruko*) that happened in things. To relate different things to each other, they needed to be ordered or classified by denominating certain common properties they possessed (Shields, 2020).

In this way, he developed a taxonomy (Sh: *govaurongwa*). Greek philosophers of the time used the terms 'eidos' (Greek: idea) later translated into Latin as 'species' or appearance, in English (Sh: *cherechedzo, chinongedzwa*); and 'genus' (Latin: type, family, race, (Sh: *mhando*) as classification terms. This is what lies under the biological taxonomy system of de Tornefort (1656-1708) and Linnaeus (1707-1778) used today.

Aristotle also argued that there are some first principles (Gk: archai; Sh: *nhangerevo*) beyond which there can be no proof of whether or not they are true, but their correctness is self-evident, requiring no further interrogation. Such first principles can apply universally across all domains or to specific knowledge domains. For example, in Logic, something cannot be true and false at the same time, so that the first principles of logic are fundamental to reasoning across all knowledge domains. In a specific domain like mathematics, a straight line is the shortest distance between two points, so that this first principle of mathematics is unique to that discipline. This definition may not be true in geography, for example where a straight line may go over mountains and ocean floor or may be curved on the earth's sphere. It is these first principles that segregate knowledge domains or disciplines from each other. For example, the first principles (Sh: *nhangerevo*) of chemistry relate to the properties of an electron, whereas for physics these relate to the atom as a whole. In biological subjects they relate to the cell and so forth. In this way, the idea of a knowledge discipline (Sh: *davi rezivo*) was created.

Aristotle's thought and wrote about causation (Sh: *sakiso*). The goal or purpose of having knowledge is to understand or explain; to explain why things happen as they do, to establish their necessity in existence. However, what counts as an explanation (Sh: *tsonzoro, tsanangudzo*)? For Aristotle, the ability to say what

(Sh: *chii?*) something was (facts) and the why (Sh: *saka, ndava*) it was that way, the cause, was the basis of an explanation. He gave four classes of causes: the intrinsic property of the constituent matter (Sh: *vako*), their physical properties; their form, shape or structure (configuration) (Sh: *umbiro*); the agent (Sh: *itiso*) that acted on them and finally the end goal (Gk: telos; Sh: *nangwa*), purpose or aim of change. These he called:

(1) material cause (Sh: *saka revako*),
(2) formal cause (Sh: *saka reumbiro*),
(3) efficient cause (Sh: *saka reitiso*), and
(4) final cause (Sh: *saka renangwa*).

There can be no explanation, according to Aristotle, without a discussion of the essential characteristics of the thing in question, its form, agent and purpose. Although Aristotelian thinking was largely abandoned in the 17th century, the system of logical thinking it created for science endured (Plitz, 1981).

Because any discussion or exploration into causes had to relate classes of things and to structures of argument, it was important to establish definitions (Sh: *duraurevo*). Aristotle's definition was essentially that this was a statement with a 'universal' and a specific premise. The universal part is a general statement (Sh: *urehwa, chirehwa*) that says the kind of thing something is, what class (genus, *mhando*) of things it belongs to. The specific premise will state in what way it differs from others in its class. This is essentially the structure of a definition today, eg: (genus, *mhando*) **a triangle is a plane figure**, (species, *cherechedzo*) **constructed from three straight lines**.

Experimentation (Bviroedza)

The Greeks developed mathematics to a high degree (Lloyd GER, 1973) and through it, measurement (Sh: *mapimiro*). Astronomy is a discipline that relied on measurement and calculation or computation (Sh: *hwerengedzo*), but the phenomena (Sh: *chionekwa, oneko, chionwa*) to be studied in astronomy did not lend themselves easily to much experimental study. The Greeks therefore tended to work based on theory (Sh: *fungo, ruoni*) and create models (Sh: *mufano, rufaniko, mutodzaniso, musekunge*) based on 'universal' truths.

Whether they conducted experiments, as we understand them today, is highly contested (Lloyd, 1964; Mayo, 2019). It has been argued that they used observation and 'experiments', not to test a theory and discover new knowledge, but to prove or disprove an argument. These experimental efforts have been described more as 'test' (Sh: *muedza*) or demonstration (Sh: *muratidzo*) than as a formal experiment.

One view of the history of science sees it as a product of a specific time and culture in each society. As a result, one can talk of German science or American science or Greek science, each being underpinned by specific local historical context, culture, resources, religion etc. On the surface, the products of such science may be similar or comparable but in their internal structure there are essential differences. From this perspective we can argue that Greeks did conduct experiments, but they had no theory of experimentation.

In the context of the time, resources available to them, their critical view of the role of observation in gaining knowledge about the world, and the nature of their society, they did perform theoretical (thought experiments) and practical demonstrations of their ideas. The Greek 'experiment' was different from later developments. The alternative view takes history as single narrative curve of accumulating knowledge into which all cultures pour their contributions, which would discount Greek experiments as judged by the linear development of science.

The emergence of Islam (610 CE) in Arabia and the Arabian Peninsula (711 CE) set in motion a series of events that led to the establishment of a new political and cultural force in the Mediterranean World. By 850CE much of the old Roman and Persian empires in the Middle East and North Africa were under Muslin control. The inheritance of Roman and Greek culture and infrastructure, Persian Empire and administration, libraries and access to India and China through the Silk Route made the new empire a melting pot of ideas and cultures.

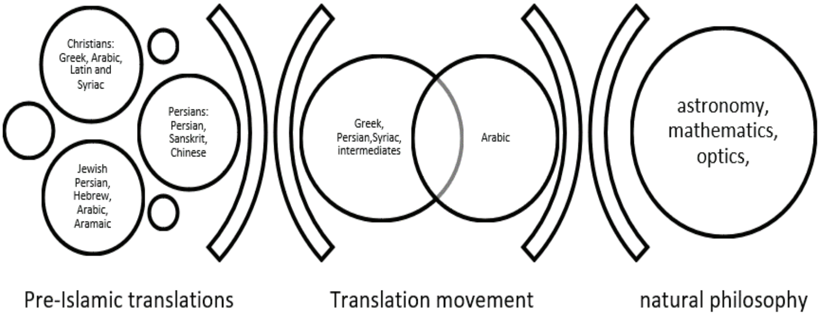

Figure 2 Chiumbiko: Translation movements, pre-Islamic and Islamic

The dispersed communities from the Eastern Roman empire were competent in Greek, Syriac, Latin, Hebrew and other Mediterranean languages. They became active in the translation movement that emerged in Persia first, then in the Islamic states that emerged (see Figure 2) (Plitz, 1985). This 'translation movement' was based in Baghdad, and Greek texts were made available in the Moslem world (Endress; 2002).

In addition to developing mathematics, astronomy and other fields further, the next step in the development of experimentation took place here. In this way we can talk of an Islamic science (Gutas, D; 2002). Al-Haytham lived from 965-1040CE. He was a mathematician and, like other scholars of his time, studied astronomy and optics (Boudrioua et al., 2020; Zubairy, 2016). He rigorously applied mathematics to a variety of problems current at that time such as the motion of the planets.

Al-Haytham is credited with deliberately, and systematically constructing experiments and using them as a distinct method of proof (Wee, 2016; Omar, 1979). In early Arabic translations of Greek authors, 'observation' (Aristotle's pepeiramenoi) was translated as *rasad* and 'experience' (Aristotle's 'empeiria') as *tajriba*. By the end of the first millennium (1000 CE), i'tibar was replacing tajriba and had a distinct meaning: that of *testing by comparing one observation with another with the use of instruments* (Sh: *shandidziro*) (Endress 2002; Gutas, 2002).

Observation

Parts of Iberian Peninsula, such as Toledo, which had been conquered by Moslems, were reconquered by Christians after 1085 CE, bringing significant Islamic scholarship into the Latin Christian world. Translations began into Latin, not only of Islamic scholarship, but also of available Greek learning (the Christian Church in Western Europe was Latin speaking). It is from this Latin translation movement that the scientific terminology in Europe springs from (Plitz, 1985). A new vocabulary had to be developed to absorb the new words from Arabic and new translations from the classical Greek, which pushed Latin further from the classical Latin of the Romans.

This rush of new learning led to 'observation' and 'experience' being the leading edge of philosophical thinking called empiricism (Sh: *ushwirozivo*), valuing 'experience' as the source of all knowledge (Thorndike, 1914; Klein, 2020). There emerged the idea that there were 'universal laws of nature governing objects' (Sh: *mhiko dzeusikwa*) and a 'general theory of science' (Sh: *fungo rezvose remarongozivo*). To the fore came reasoning by induction (Sh: *nharidzo*), identification (Sh: *fukuro*) and elimination (Sh: *kurasa, kubvisa*) of bias (Sh: *usaru, rurerekedzo*) in scientific investigation, and following through scientific knowledge with new inventions and theories.

In this new conception, observation (collection of facts) came first, then systematic organization and study of the facts leading to development of hypotheses (Sh: *pikazano*), including systematic experimentation leading to axioms or theories which can be subjected to hypothesis testing (Sh: *edzazano*) through systematic study. Descartes (1596-1650) further proposed four principles which he suggested are essential to the experimental approach. The first was not to accept anything as true, in other words to approach a problem with an element of doubt (Sh: *zvirosava, kusavazviro*), uncertainty (Sh: *kusavaneidi*) or skepticism (Sh: *rusatendero*). The second was to reduce or divide the problem into a series of questions (Sh: *kupatsanura, kutezenura*) so that the whole problem is addressed one question at a time (Sh: *kudededza*). The third was to structure the available knowledge stepwise (Sh: *danhadzira*) from simple to complex, not only demonstrating how everything fits together but also identifying where the gaps in knowledge are. Finally, was the necessity and ability to comprehensively summarise the knowledge (Sh: *gombedza*) (Vignais & Vignais, 2010). With this, essentially, experimentation now had a theoretical basis from which it continued to develop.

.

Mathematics (Dzidzo yeukamaruswa)

The early history of mathematics begins with the need to quantify (Sh: *ruzivo rwe uwandu*) activities in the environment (http://www.taneter.org/math.html). These may be things that can be counted such as number (Sh: *bodzwa, nhamba,*) of days and those that cannot be counted which required measurement (Sh: *upimo, mupimo*), such as time or length. Although all human cultures have been shown to use computation methods, the earliest records date back to the ancient Egyptians who developed written number system (Sh: *murongabodzwa*) and units of measurement (Sh: *bodzi rechiero*) such as cubit (length of forearm from elbow to fingertip). They developed and used methods of computation for areas (Sh: *ruhwaro, mukwasvati*) of various shapes (Sh: *muvakwa, muvangwa*) using an abacus for addition (Sh: *sanganiso*), subtraction (Sh: *bvisaniso*), multiplication (Sh: *virikidzo*) and division (Sh: *govaniso*).

Such arithmetic computation was essential for surveyors who determined land sizes and yields for taxation and payments for services. The next documentary evidence shows the Babylonians at the next step in about 1800BCE. They developed and used a number system, aspects of which we still use today for measurement of time (Sh: *nguva*) and angles (Sh: *rumhandi*), as well as framing computational problems as equations (Sh: *nengairo, dengezo*). They also developed skill in manipulating geometrical shapes; calculating areas and volumes (Sh: *uzadzi, ugombwa*) of different shapes. At this time mathematics can be described as the study of numbers (Sh: *bodzwa*) and shapes (Sh: *mivakwa*).

Many of the early theoretical properties of numbers (arithmetic) and shapes (Gk: geometry) were well known but there was no understanding of mathematical 'proof' (Sh: *matanho ebupuro*). This was the next major contribution to mathematics provided by the Greeks (Lloyd, 1973) and the move away from mathematics as accounting to an analytical tool. The term 'mathema' to the ancient Greeks meant 'what one learns' (Sh: *dzidzo*) and today in modern Greek it is the term used to mean 'a lesson' (Sh: *chidzidzo*). Until Aristotle, it was also used in a similar way as 'episteme' above to mean 'knowledge'. He was the first to separate it as a 'study of quantity' (Sh: *ruzivo rweungani*) and to show that it has specific characteristics which made it a separate disciple, a 'science'. Well into the European Middle Ages it was studied together with 'natural philosophy' and astronomy. Mathematics developed as a theoretical (e.g., Pythagorians) and practical discipline (Archimedes) till it was taken up by the Islamic thinkers. In science, it was wedded to astronomy and optics above all. Islamic mathematicians replaced the use of letters (by the Greeks) or Roman numerals with the Indian numbering system and introduced decimal system into mathematics making calculations (Sh: *ziva ungani*) easier and more accurate (Sh: *ruramisiso*). They also developed the mathematics of equations beyond what the Babylonians had achieved into a general system of algebra (arithmetic without numbers).

Galileo Galilei, who was a professor of mathematics and philosophy, argued that 'the language of the cosmos was the language of mathematics…' (Rheinberger, 2001; Vignais & Vignais, 2010). From the numerous experiments he constructed, such as for free falling bodies, he developed mathematical formulae. They were very useful for deriving secondary systems or units of measurement (Sh: *bodzi remupimo*), such as density (Sh: *utsokodzi*) (d=m/v: mass/volume) which would not be immediately apparent from knowing the mass (Sh: *gwada*) and volume of a substance.

New relationships became apparent, such as between time (Sh: *nguva*) and velocity (Sh: *hurumidzo*) of a falling body. Mathematicians had speculated about the relationship between distance travelled by a falling body and speed (Sh: *uchimbi*) since early Greek times, the relationship with time was only established for the first time by Galileo. With formulae (Sh: *muronga, fomura*), theory generation for constructing new experiments and new theoretical models of explaining the world (de Berg, 1992) became possible. The development of calculus was a great step for science as change could now be followed with calculations to an infinitesimal degree. Mathematics has remained in this relation with science ever since (de Berg KC, 1992). Other developments in mathematics would lead to it being redefined as the science or the study of patterns (Sh: *nyereketo*) or relationships (Sh: *ukamaruswa*).

Conclusion (Mheto)

Essentially, experimentation now had a theoretical basis from which it continued to develop, and this was accompanied by exponential growth in knowledge in general and scientific knowledge in particular. Alchemy developed into chemistry and natural philosophy into physics, while biology emerged as a discipline. Craftsmanship (Gk: techne; Sh: *umhizha*) could also develop a scientific knowledge base for technical disciplines such as Engineering and Architecture. Measurement emerged as a discipline, metrology (SH: *zivoroupimi*), for the construction of measuring instruments, developing methods of scientific measurement and integration of mathematics into experimental design.

From these, all the disciplines we know today emerged. It became clear gradually that biology, including humans, operated under the same physical laws of nature as physics and chemistry, and that structure and function could be explained in the same mechanistic way as machines that were being built. Biology developed further principles of experimentation of its own, such as the 'controlled' (Sh: *musunganidzana*) experiment to account for single interventions in a complex system and introduced ethics (Sh: *nduramo*) into the discourse.

The methods of natural philosophy were taken on by 'moral philosophy' (Sh: *nyarudezivo yenduramo*) disciplines much as Socrates had done, so that specific social phenomena could be identified as objects (Sh: *chiro, chionekwa, oneko*) of study through observation and measurement. This came to define what a social science was and from that emerged, first sociology then economics and more.

Alongside this growth was, of course, vocabulary. Greek, Arabic and Medieval Latin and the European languages that supped on the word-horde demonstrated the agility of language in giving voice to new ideas. African languages have just as much ability, which we have demonstrated above.

Appendix / Chiwedzerwa:

1. **Abstract***: Latin: from 'abtrahere': ab – off, away, trahere – to draw, to move, to drag. Greek (as Aristotle used it): 'aphairesis': to take away: 'aph' – off, away from. 'haireo' – take, snatch.. ChiShona: '-bva'- from; -bvisa- take away; -minima, -susunha, -susudza. So, abstract: minimisa, minimidza; susudza, susudzisa; abstraction: minimidzo, susudzo*
2. **Argument:** *Latin: argeure, to make known. Greek: Aristotle described his statements of argument as 'syllogismos', referring specifically to the deductive argument. ChiShona: 'pikisano' is nearest to modern term of 'argument' and 'pikiso' being equivalent to 'premise'. Latin: 'Premise' prae: before, mittere: to send, meaning to state something (first) from which another follows. ChiShona: gakava, kakavadzano, mbava, ngani, nharo,* **pikisano** *– kutaura kunoita vanhu vachiratidza kusawirirana,* **pikiso** *mazwi anotaurwa nemunhu anosiyanisa nezvinenge zvichisiyana nevamwe.*
3. **Arithmetic***: Greek: arithmos meaning number, counting, amount gave arithmetikos, meaning of rekoning/counting and arithmetike (tekhnē) counting (art), art of computation.*
4. **Astronomy***: Greek: astronomia meaning 'astro' (star), nomos (arranging, regulating, law, rule). Latin: astronomia meaning star-regulating. From 1200 CE astronomy meant 'study of heavenly bodies'. ChiShona: dzidzo/fundo/ruzivo ye matenga, nyenyedzi/ nyeredzi, uzuru (ruuzuruzivo).*
5. **Calculate***: Latin: calculate come from the Latin 'calculare', which meant to count (reckon) using a stone (pebble / calculi) such as on an abacus. The stone itself was a calx. ChiShona: rava, verenga, (count), hwerengedzo (collection of items for the purpose of counting)*
6. **Cause***, Latin 'causa', 'a reason'. ChiShona: konzero, sakiso chisaka. Greek: telos – end, logos – study: teleology - study of the 'end causes' as developed by Aristotle.*
7. **Classify***, Latin 'classis', 'to group'. ChiShona: 'kuronga muzvikwata' 'murongomakwata', taxa (Greek)- arrangement; nomia – distribute.* **taxonomy***: ChiShona: rongwa - arrangement, kugovera- to share, distribute; urongwaugove*

8. **Definition***: Greek: orismos – boundary. Latin – de- completely; -finire – to limit; ie to set limits (of meaning). Modern meaning of definition includes the sense of explanation of the meanings of words. ChiShona: ganhu - boundary/limit; reva -say, bring out; dura- reveal meaning –. The sense explanation of meaning the word used in ChiShona is duramazwi: 'dura' 'tell the meaning', 'izwi'- word. Durarevo. Genus: mhando, rudzi; species: chinongedzwa, chiratidzo***Explain***, Latin 'explanare', 'to make things intelligible'. ChiShona: tsanangura*
9. **Demonstration***: Latin: 'de' – entirely, and 'monstrare' – to point out, to reveal, to show. ChiShona: kuratidza (to show, point out, reveal), chiratidzo (a showing), -ratidzo (reveallation) kuratidza (to reveal, to show), bangidziro (sudden show as in 'a flash').*
10. **Dissect***: Latin: dis – apart; secare – cut. Dissection: act of separating anything into distinct parts for critical examination. ChiShona: kupatsanura (uchi / ne kuongorora)*
11. **Experience***: Latin: ex – out, from; -perior – try, dare, risk; experior – from experience. (out of experience); experiment – to find out by trying; ChiShona: out / from – \bva \bvira \buda; try/dare/risk - \edza \vavarira \bviroedza \ bvirovavariro. Aristotle would have used the term pepeiramenoi which means observation, or a procedure (test: peira) that would have allowed 'demonstration' (of a theory). The term experiment is a Latin translation of a new term that was developed by Arabic scholars (see later).*
12. **Explain***: Greek: exigisi -explanation, interpretation. Latin: explanere – explain: ChiShona: tsanangudzo / tsananguro, (ma)tsonzoro*
13. **Formula***: Latin: 'formula' a rule, contract, method, recipe. ChiShona: -sungo, tevedzero, nzira.*
14. **History***: Greek: historia – enquiry, knowledge from enquiry, judge Latin: historia (from Greek) to mean investigation, inquiry, research, account, description, written account of past events, writing of history, historical narrative, recorded knowledge of past events, story, narrative ChiShona: ugo, matsotso*
15. **Infinity***: Greek: Apeiron: 'boundless' ChiShona: kusaguma, husaguma; kusapera, husapera. The earliest known such coinage was by Aneximander, who took the term apeiron, which means 'boundless' as an adjective and used it as a noun to mean 'infinity'.*
16. **Knowledge***, from Old English 'knowen' (to know, recognize. Greek 'gnosis' meaning 'awareness, insight'. In ChiShona the equivalents would be 'kuziva, to know', 'ruzivo, knowledge'. Knowledge from experience:* **ushwiro***: ruzivo rwunobva mukurarama, muhupenyu, murugariro: uraramizivo, ushwirozivo*
17. **Matter***: The Greeks had no general word for 'matter'. Initially the early philosophers used the term 'rhizomata' meaning 'roots' (mudzi), as in the 'origin' (vamba, vambiro) of something. Later, the word 'stoicheion' was used, meaning 'a letter (ie element) of the alphabet'. A ChiShona word for 'element' could be 'ruvambiro'. Aristotle used the word 'hyle', meaning 'wood/timber' to indicate 'whatever can be shaped into something, given form', or the material from which things are made. Latin translators in medieval Europe translating from Aristotle chose the Latin word 'materea' over more specific word to carry the sense of 'substance' rather than wood/timber. English: substance, matter.*
18. **Measure***: Latin: metiri, meaning 'to measure' and mensura 'measure'. ChiShona: pima, yera (measure), kupima, kuyera (to measure), mupimo, chiero (a measure),*

mupimo (measurement)

19. **Observation***: Latin: observare: to follow a course of conduct. ChiShona: kuteerera: (1) to obey, to follow, follow instruction, (2) to listen, pay attention (deveredzo)*
20. **Phenomenon***: There are three Greek terms which are associated with the term: phainesthai (to appear), phainein (to bring to light), phainomenon (that which appears or is seen). The English term is derived, via its Latin form from the last. ChiShona: kuoneka, kuonekera, chioneko, chionekero. Phenomenon = oneko*
21. **Philosophy***, from the Greek: philo- love, like (ChiShona: -da, kuda, rudo, mado, nyarude) and sophia- wisdom, (ChiShona: -unjere, ruzivo, ungwaru). Zvekuti tingati enzanise izwi 'philosophy' nezwi 'madozivo' kana 'nyarudezivo', 'madoungwaru'*
22. **Physiologos***: discussion about the natural world (nature) (kunze, panze). ChiShona: nhaurodzezvekunze, nhaudzodzezvekunze*
23. **Principles:** *Greek archi – origin, beginning, inception. Latin: principium / princeps – source, foundation, first. English: modern use 'principle': basic assumption, rule of conduct. ChiShona: (ma)vambo (beginning), muko (rule of conduct, basic assumption)*
24. **Prognosis***: pro- (before) gignoskein (to know) foreknowledge, ie to know before, or ChiShona fanoziva.* **Symptom***: Greek: syn (together) piptein (to fall) mean happenings that fall together* **Diagnosis***: Greek: dia (between) gnosis (to know) diagnosis, i.e. to know exactly and distinguish from others;* **Therapy***: Greek: therapeia, curing, healing, service to the sick, take care of sick.*
25. **Reason***, is derived from Latin. Aristotle would have used the term 'logos'. The English term 'reason' is derived from Latin, meaning 'to think in a logical manner', in ChiShona 'mafungiro', way of thinking. Heraclitus was first to use the term 'logos' in the sense of a 'structured discussion' for organizing knowledge. Prior to this it was generally used in the sense of 'word, voice, pronouncement' [izwi, mazwi, zvarehwa]. Aristotle (much later in time) used the word in the sense of 'reasoned discourse' [hurukuro, kurukurano, nhauro (discussion, dialogue), tsetsenuro (explanation), dononguro, tsoropodzo (criticism)].*
26. **Science:** *Greek episteme, English: systematic knowledge, ChiShona ruzivo (knowledge) rwaka tsetsenurwa (that is organized, systematized) (ruzivotsetse), Latin: scientia (knowledge)*
27. **Technology***: Greek: techne meaning craft/art of 'knowledge related to the doing of something', i.e., practical skill. ChiShona: gona, kwaniso (knowledge or ability to do something), skill in making something: umhizha, unyanzvi; English: craft (to make something with skill: kugadzira neunyanzvi / rugadzi*
28. **Theory***: Greek 'thea' (a view), horan (to see) which meant 'to view' something, as in an action (hence theatre), which developed into 'mental viewing' as in 'to speculate, to consider etc hence 'theory'. From the Latin borrowing it became 'a mental conception, scheme etc). ChiShona: as in 'maonero' (way of seeing, point of view, opinion, perspective), Ruoni.* **Optic***: Greek: optikos: having to do with sight and Latin: pertaining to the eye. ChiShona: uoni*

29. **Universal**, *from Latin: 'pertaining to everything everywhere'; Chishona: kuva zvose kwese or zvakwesenezvose. kweserose, zveserose. 'Knowledge that is correct universally eternally' 'Ruzivo rwuno vimbika/tendeka pazvosenekwese narinhi / zvachose' Eternal from Latin: 'age' then 'great age' then 'everlasting'. ChiShona: narinhi, zvachose.*
30. **University**: *Latin: universitas - a number of persons associated into one body, a society, company, community, guild, corporation; the whole, aggregate, entire. The earliest universities were therefore 'universitas of learning'*
31. **Volume**: *Latin: 'volumen' was a scroll as in an ancient book written on a roll of pyparus. Later it came to mean 'size of book' and then generally 'amount' or 'size' of something, hence 'volume' as in bound volume of book.*

Glossary (Jekeso)

English	*ChiShona*
abstraction	susunho
acceleration	ukasikidzi
accuracy	ruramisiso
agent	itiso
analysis	ongororo
angle	rumhandi
area	ruhwaro
argument	pikisiro
axiom, principle	revo, muko
bias	rurerekedzo, usaru
calculation, computation	hwerengedzo
cause	sakiso
cause, efficient	saka reitiso
cause, final	saka renangwa
cause, formal	saka reumbiro
cause, material	saka revako
change	sanduruko
comprehensive	gombedzero
conclusion	gumisiro
contemplation	kufunga, kupanga
deduction	masunha

English	*ChiShona*
definition	duraurevo
demonstration	muratidzo
density	utsokodzi
diagnosis	durautenda
discussion, discourse	nhaurirano
doubt	rusatendero, zvirosava, kusavazviro
earth	pasirose
element	vambo
elimination	kurasa, kubvisa
empiricism	ushwirozivo
enquiry	tsvakurudzo
episteme	ruzivo
equation	ekwezheni, nengairo, dengezo
ethics	nduramo
experiment	bviroedza, muedza
experiment, controlled	bviroedza wemusunganidzana
experience	rushwiro
explanation	tsanangudzo, tsonzoro
form	ruumbiko
form, shape	muvakwa
formula	muronga, fomura
genus	mhando
goal	nangwa
general statement	chirehwa, urehwa
hypothesis	pikazano pikidzazano
hypothesis testing	edzazano
identification	fukuro
induction	nharidzo
infinite	ruenderera, usangagumi
instruments	shandidziro
knowledge	ruzivo

English	*ChiShona*
knowledge discipline	davi reruzivo
logic	kutsikanidza pfungwa, nzira yepfungwa
logic, breakdown of	kutezenura, kupatsanura,
logic, solve questions serially	kudededza
logic, structure stepwise	danhadzira
logic, comprehensive summary	gombedzo
mass	gwada
mathematics	ruzivo ukamaruswa
matter	ruvambiro, vakisi, munyakwe
measurement	mapimiro
measurement, unit of	bodza rechiero, bodzi rechiero
metrology	zivoroupimi
model	mufano, rufaniko, mutodzaniso,
	musekunge
nature	usikwa, kunzerunze
nature, laws of	mhiko dzeusikwa
number	bodzwa, nhamba
number system	murongabodzwa
observation	matariro, matarisiro chaonwa
object	chiro, chionekwa, oneko
optics	uoni
origin narrative, history	ugo
pattern recognition	cherechedza musambo
personal life	ugaro, uraramo, magariro
phenomenon	chionwa, oneko, chionekwa
philosophy	nyarudezivo
philosophy, moral	nyarudezivo yeururamo
philosophy, natural	nyarudezivo yeusikwa
premise	pikiso
principle, axiom	revo, muko
principle, first	nhungarevo

English	*ChiShona*
prognosis	dudziro
proof	matanho ebupuro
reasoning	mafungiro, nzira
reality	uvapo
relationship	ukamaruswa
science	murongwazivo, ruzivotsetse
science, general theory of	fungo rezvose remarongozivo
scepticism	rusava netendero
senses	manzwisa
serialise	kutezenura
society	ugari muruzhinji
sphere	hurungo
species	cherechedzo
speed	uchimbi
stepwise	danhadziro
symptom	chiratidzi
tabula rasa	saroziva
taxonomy	govaurongwa
test	muedzo
technology	ungwaru hweumhizha
theory	fungo, ruoni mafungo
thinking	kufunga
therapy	urapi
uncertainty	kusavaneidi
understanding	rugutsikano
universe	kweserose, govakomba redenga
velocity	huchimbidzi
volume	gombwa, uzadzi

References

ChiShona Reference sources:

Chetsanga C. 2014. *Duramazwi resainzi nehumhizha reChirungu neChishona*. Harare. Longmans

Chimhundu H. Ed. 2001. *Duramazwi Guru ReChiShona*. Harare: College Press.

Hannan, M. 1984. *Standard Shona dictionary*. Harare: College Press

Manyame B. 2015. *Denhe reutano neurapi*. Harare, Kagondya Books. Duramazwi reurapi. Harare, Kagondya Books.

Manyame B. 2018. *Denhe neDuramazwi zveUtano neUrapi*. Gweru: Mambo Press

Manyame B. 2013 *Tsvakamazvifanana*, Manyame [self-published]

Mpofu, N. H. et al. (Eds.). 2004. *Duramazwi reUrapi neUtano*. Gweru: Mambo Press.

References / Jerero

Aristotle. 1984. Organon. In Barnes J (series Ed). *Complete works of Aristotle*. Bollingen Series Edition.

Curd, P. 2020. Presocratic philosophy, In Edward N. Z. (Ed.), *The Stanford Encyclopaedia of Philosophy* https://plato.stanford.edu/archives/fall2020/entries/presocratics/ Accessed 22 Jan 2022)

Bäck, A. 2006. The concept of abstraction. *The Society for Ancient Greek Philosophy Newsletter*. 376. https://orb.binghamton.edu/sagp/376

Cleary J. J. 1985. On the Terminology of 'Abstraction' in Aristotle. *Phronesis* 30(1): 13-45

de Berg KC. 1992. Mathematics in science: the role of the history of science in communicating the significance of mathematical formulism in science. *Science in Education*, 1: 77-87.

Endress, G. 2002. The Language of demonstration: Translating science and the formation of terminology in Arabic philosophy and science. *Early Science and Medicine*, 7(3).

Gutas, D. 2002. Certainty, doubt, error: comments on the epistemological, foundations of medieval Arabic science. *Early Science and Medicine* 7(3): 276-289

Hall, E. 2014. Introduction: The characteristics of the ancient Greeks (pp. 1-29) In Bodley, H. (Ed.) *Introducing the Ancient Greeks: Ten ways they shaped the world*. London: WW Norton

Kraut, R. 2017. Plato. In Edward N. Z. (Ed.) *The Stanford Encyclopaedia of Philosophy* https://plato.stanford.edu/archives/fall2017/entries/plato/

Lloyd, G. 1970. The background and the beginnings (Ch 1). *Early Greek Science: Thales to Aristotle*. London: Chatto and Windus.

Lloyd, G. 1992. Methods and problems in the history of Ancient Science: The Greek Case. *Isis* 83(4): 564-577

Lloyd, G. 1964. Experiment in early Greek philosophy and medicine. *Proceedings of the Cambridge Philological Society New Series*, 10(190): 50-72.

Lloyd G. 1973. Hellenistic mathematics (Ch 4) in *Greek Science after Aristotle*. London: Chanto and Windus.

Mayo, T. 2019. Research and experiment in early Greek thought, PhD dissertation, University of Michigan. https://hdl.handle.net/2027.42/150050.

Piltz A. 1981. *The world of medieval learning*. Oxford: Blackwell.

Shields, C. 2020. Aristotle, In Edward N. Z. (Ed.) *The Stanford Encyclopaedia of* Philosophy https://plato.stanford.edu/archives/fall2020/entries/aristotle/.

Thorndike, L. and Roger, B. 1914. Experimental method in the Middle Ages. *The Philosophical Review*, 23(3):271-298

Rheinberger, H. 2001. History of science and the practices of experiment source. *History and Philosophy of the Life Sciences* Special Issue in Honour of the late Mirko D. Grmek 23(1): 51-63.

Vignais, P. V. and Vignais, P. M. 2010. *The roots of experimental science from* ancient Greece to the renaissance. Discovering life, manufacturing life how *the experimental method shaped life sciences*. Dordrech: Springer.

Zubairy M. S. 2016. A very brief history of light. In Al-Amri, M. D, El-Gomati, M. M. and Zubairy, M. S. (Eds.) *Optics in our time.* (pp. 4-23)., Springer Open. DOI 10.1007/978-3-319-31903-2-1.