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TOOLS AND SOURCES OF ENERGY FOR FARM FORCE MACHINES: A CLARIFICATION AND DISTINCTION FROM SIMPLE MACHINES AND SOURCES OF POWER FOR FARM WORKS.

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ABSTRACT

Education is good, but good education is an asset of inestimatable value. It is in the light of this fact that this paper is put together to appraise some technical terminologies/terms inappropriately expressed, used in text and taught at Basic Education and Secondary Education as well as many tertiary institution levels within and outside of Nigeria. Some examples of the terms are tools, implements, equipments, simple machines, machines, engine/motor, sources of power for farm works, sources of energy, technical work, farm/agricultural work, machinery, etc. In view of the fact that the Basic Education level is very crucial in the moulding of the knowledge of the citizens, it becomes necessary and greatly expedient to ensure that only appropriate instructions are given out. Hopefully, this paper shall be a contribution to intellectual discourse. However, the focus is on simple machines and sources of power for farm works. It is an original scholarly review work which ends by proposing the drawing of attentions of the various authors, publishers, teachers at all levels of Science and Technology learning/study and government education management agencies, etc. to the facts, with the view to making necessary adjustments.

Keywords: Energy, Machines, Power, Sources, Tools, Work

1. INTRODUCTION

We must be able to separate natural phenomena that are taking place regularly in the environment from the work we design to do in the field of agricultural production (crop and livestock husbandry). Can we say that the pollination of flowers of crops is

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farm work done by wind power? It is certainly not. Can we say that logs of timber harvested and dumped into nearby flowing/moving water of Rivers which then transport or float them to somewhere else is farm work done moving water power? The answer is of course, no.

Furthermore, can we say that produce and products of farm left to dry up in the open air under the direct effect of sunlight and heat is farm work done by solar power? The answer is no. If it had been yes, what about the influence of the moving air, relative humidity of the atmosphere, etc? Can we say that chaff and grains/seeds mixture separated by free fall into grains/seeds somewhere and the chaff elsewhere in a little distance away is farm work done by wind power? It is certainly not. These are few examples.

The above are all natural phenomena regularly occurring in the environment whether in farm, street, open fields, desert, bush/forest, house compounds, etc wherever air mass is in motion and flowing water mass move things around. These can belong to what the authors might want to refer to as **technical work** as defined by laws of **physics** and not farm work. Whereas the drying falls into the physical and physiological processes of heat absorption, transformation from liquid to vapour state and evapo-transpiration that makes materials expose to sunlight and heat to lose their moisture content and shrink (become smaller in size) and sometimes also to deform in shape (compression).

Careful observation and consideration would reveal to us that:

i. the spreading of harvested produce and products for drying under the sun and removal of the dried materials are done either manually (human being) or driven on platform by mechanical device, otherwise it is natural that all materials get dry. **Thus, the actual work is not the drying but getting the materials from farm to dry. This is the farm work;**

ii. the raising of grains/seeds and chaff mixture for free fall for moving air (wind/breeze) to remove the chaff from the grains/seeds, bagging the clean grain/seeds and disposing the chaff are done either by human being or by mechanical device;

iii. the movement of logs of timber/wood into nearby river for transportation elsewhere is done either manually or dragged by mechanical device and the control of the floating/movement of the logs in the right path in the water is done manually using paddle or dragged along by paddled canoe, engine/boat, etc.

These are issues for serious academic discourse in view of the expressions in so many academic textbooks. Before going into what the authors consider to be the most proper direction, it would suffice to go into

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literature review wherein examples of the appropriate terms being treated in this work shall be highlighted.

2. LITERATURE REVIEW

According to [1];[2], "Farm Power", various types of agricultural operations performed on a farm can be broadly classified as (1) tractive work such as seed bed preparation, cultivation, harvesting and transportation, and (2) stationary work like silage cutting, feed grinding, threshing, winnowing and lifting of irrigation water. **These operations are done by different sources of power, namely human, animal, oil, diesel engine, tractor, electricity and wind"**. Also refer to details in sub-chapter 1.5 page 17 and in unit 1.5.1 of [2] the authors stated "Traditional agriculture was mostly dependent on non-commercial **energy sources**. However, in modern agriculture, commercial energy sources contribute bulk of the energy supply to production agriculture and more so in post-harvest applications. During the early stages of 'Green Revolution' the demand of commercial energy was greatly felt with increasing use of diesel, fuel and electricity in Indian farms". In sub chapter 1.6 page 18 also of [2], the authors stated **"Wind power**. Wind energy has been in use for thousands of years to propel boats and ships and to provide rotary **windmill power for lifting water and grinding grains"**. In subchapter 1.7 therein Hydro-powers; the authors stated "Flowing water in canals, rivers and stream can be harnessed to convert hydro-power to mechanical or electrical power system. Hydro-power is an important source of generating electricity in Indian".

It can be seen from the above citation that the inter-change usage of power and energy is inappropriate and there seems to be some elements of confusion of the content/concept of power and energy. The question falling out here is whether power or energy means the same thing [3]. If not, the question is whether they have a converging point and if they do, at what point and in which technical situation/process do they?

[4] (tenth edition) on page 221 stated thus "Three major shifts in source of field power have been human and animals, animals to external combustion engines (steam) and external combustion engine to internal combustion engines. Doubtless within the lifetime of many presently living, a fourth shift will occur. Very likely the future **power shifts** will be turned by electricity but the source of **electric energy** may be gas turbines, fuel cells, solar cells, atomic energy or some source unknown at present". This is an example of clear distinction between power sources and energy sources for the activities of the farm power devices. This is further confirmed by the expression on page 222 wherein he stated "The application of power other than human to agriculture has been a matter of great concern through the ages. Animal power was used well before recorded history to supplement human labour. With the advent of steam power, effort were made to **utilize steam** force for agriculture"

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According to [5] in sub chapter 3.3 sources of power in Agriculture on page 49 "Power is required for almost every operation in agriculture. The sources of such power vary according to availability, the job to be done and the level of technology under which the operation is undertaken. Possible sources of power in agriculture include (i) human muscle (ii) work animal (iii) internal combustion engines (engine power) (iv) **Wind** (v) **Water** (vi) **electricity** and (vii) **solar energy"**

It is worth mentioning at this juncture that the citations above are from didactic textbooks for tertiary institutions of Agricultural Engineering Study (that is, [2]; [5]) and Agricultural Mechanization Study (that is, [4]). Below are few citations from Basic Education and Secondary Education levels textbooks.

According to [6] "Sources of farm power are electricity, animal, wind, water and heat engines". And elsewhere, the authors stated that "the various farm machines commonly used on government farms are tractors, **plough, harrows**, planters, cultivators, harvesters, feed grinder, and incubators. These statements are technically wrong. [7] wrote "Simple farm tools which are used in school gardens and farms are cutlass, axe, fork, hoe, sickle, rake, spade, shovel, watering can, trowel, and file". [8], stated that "farm tools and implements include; cutlass, hoe, spade, rake, axe, sickle, pruning saw and many others". The examples of farm tools given by the authors are not far reaching as they seem to portray farm tools or implements as only those simple handy ones when in fact there are animal-drawn and tractor coupled large size farm implements like harrow, plough, ridger etc. which universal basic education wrongly called machines. This must be the same line of thought of [7] and [8]. Accordingly to [7], "some modern farm machineries which include Bulldozer, **plough, harrow,** planters, sprayers, harvesters".

National Education Agencies in Nigeria are not spare of these errors. According to the 9-year Basic Education 2012 Curriculum Basic Science and Technology prepared by the Nigerian Educational Research and Development Council (NERDC) which is a parastatal/Agency of the Federal Ministry of Education:

i. Primary 1 on the topic Simple Machines, it is written "Simple Machines (a device that makes work easy e.g. Broom, Spoon, See-Saw/Swing, Hoe, Cutlass, etc")., and
ii. in the middle (4 - 6) and upper Basic (JSS 1 – 3) Curricula, there ought to be clear separation of the different Mechanisms of Simple Machines and Simple Machines, Lever, Pulley, Gear etc. It could have been better to say that simple machines (machines) can operate on a lever mechanism, pulley mechanism, gear mechanisms etc.

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According to [5], "Agricultural mechanization is the **development,** introduction and use of mechanical assistance of all forms and at any level of technological sophistication in agricultural production. It should be noted that agricultural mechanization is not the same as tractorization, which simply means the use of tractors for farm work. Rather, it involves the **design, development,** operation and maintenance of prime movers and devices for agricultural land development, crop and animal production, processing and storage. In Nigeria, three levels of agricultural mechanization can be identified. These include hand tool technology, draught animal technology and engine power technology" [5].

Differently, [4] (tenth Edition) and [9];[10] examined agricultural mechanization as the Exploitation and Management of machines, mechanical aggregates/installations in replacement of manual and draught animal works in agricultural production. In this way, it includes the efficient selection, operation, repairs and maintenance and replacement of **machinery.** And machinery refers to a stock of engines (source of power) and machines used in doing works in a unit of production activities [10];[11]. And whereas agricultural engineering is seen as occupying itself with designing, construction/fabrication, exploitation and management of facilities, made up of forces and materials of nature, which enhances scientific agricultural production.

The authors of this paper agree entirely with [4]; [10] as [5] appears to be mixing up tools, machines, installations, engineering and mechanization.

The textbooks that have these inappropriate usages of the technical terms (which are subject of this paper) are so numerous to be cited in journal article/conference paper, hence the above few examples would suffice.

3. MATERIAL/RESEARCH RESOURCE FOR THE STUDY

This work is an original research and a review work based on scholarly inquiry to find out the extent to which discovered errors were in use in didactic materials and whether there are also didactic materials that express what the authors of this paper hold as the correct or appropriate usage or expression of the terms referred to in this paper.

4. RESULT AND DISCUSSION

4.1 Result

The result of the inquiry reveals that the Agricultural Engineers specializing in Agricultural Mechanization understand the concept of power for farm work and energy sources than those specializing in other aspect of agricultural engineering like Farm Structure, Machinery Design and Fabrication etc. and agricultural scientists. Hence, textbooks written for agricultural mechanization study were clear and more

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appropriate than other books on agricultural engineering, on agricultural science, Science and Technology, etc. This result now leads to the meaning of the technical terms for clear understanding and distinction.

4.2 Discussion

The terms to be discussed here shall be limited and include tools and implements, simple machines and machines, engines, agricultural engineering, agricultural mechanization, sources of power for farm work, sources of energy for agricultural use or use in the farm, **technical/mechanical** work and **farm work.**

4.2.1 Technical/Mechanical Work as Distinct From Farm Work.

Generally, **work** is displacement in a unit of time under the influence of a force/pressure. Therefore, work is done when there is change in position, size or form/shape of an object and the amount of change depends on the magnitude and direction of the resultant force, on the mass and resistance of the body, on the direction of the applied force and on the point of application.

Where as a **farm work** or **agricultural work** can be defined as a specific activity to be carried out in the course of raising crops and livestock and this work can be **isolated** (that is, separated with known beginning and known ending) and can be **measured** (that is, determination of size in space and volume/quantity) and it also leads to another process or activity within the whole process of production (husbandry technology). Examples are movement of materials on the farm (within and not to or from farm), planting/seeding, and tillage (like ploughing, harrowing, ridging, cultivation), soil compressing, weeding, thinning, and rouging, pests and diseases control, vaccination in livestock, milking, wool/hides harvesting, crop harvesting, field preparation of produce for storage, post-harvest field preparation, etc. These are specific activities constituting farm work.

4.2.2 Concept of Power and Energy

Generally, **Power** is the rate of doing work, that is work done in relation to the time taken. And we have examined the concept of work in unit 4.2.1. Power is measured in units of Watts (W) or Joule per second (J/S).

Also generally, **energy** is the capacity or potential with which work could be done, that is, **stored strength** of a matter. During agitation, movement or burning chemical breakdown or build up, the stored energy **develop into power through mechanical conversion** (whether inside of human body system, animal body system or engine system) and drives the execution of work in farm or outside the farm. Energy is usually stored in matter in chemical form from which burning heat and pressure/force is generated and they create **mechanical work**. Energy is measured in unit of joule (J). A joule is the energy expended when a force of one Newton moves a body of one Kilogram

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mass through a distance of one meter in a time of one second [12].

$J = Nm = Kgf.m^2/s^2$ where one Newton is the amount of force that moves one kilogram mass body to a distance of one meter in a time of one second, that is, $N = Kgf.m/s^2$.

"**Force** is that action which causes or tends to cause motion or a change of motion of an object. To describe a force completely, its direction of action, magnitude and point of application must be known. What is commonly referred to a "force" is really two forces. Since force never are present singly, but always in pairs. The two parts are called **action** and **reaction**. These two parties are always equal in magnitude, but opposite in direction" [13]. This mean that the weight of an object also constitute a force or resistance to the force acting it, and weight of an object is given by the mass of the object multiplied by the gravitational pull (force of gravity).

$F = ma, in\ N = Kma, in\ N$

Where K is constant

$Weight = mass\ (m) \times$
$forceof\ gravity\ (g)$

$g = 9.8m/s^2 \Rightarrow 9.81kgf/m^2$
$= 9.81Newton\ for\ a\ kg\ mass\ object$

Mass is the amount of particle or matter in a body and it is constant for the same body anywhere on earth. But weight is the mass as influenced by force of gravity. And because force of gravity varies from place to place on earth (earth not being completely spherical but flattened in some places), the weight of the same body also varies from place to place [13].

Force can also be said to be the strength or intensity of pressure of a body acting on another body with which it is in contact and it influences either the binding of the bodies or the production of motion/change of motion. One most simple example of force seen on the farm is the direct pull or pushes which the tractor exerts on implement while moving forward or backward (pull and push respectively) [13].

4.2.3 Sources of Power For Farm Work.

Arising from the list of examples of farm work, meanings of work and farm work and the concept of power and energy discussed in units 4.2.1 and 4.2.2 above, farm works are either done **solely manually** (human power) or human power in control of Tamed big size four-legged animals (specific animal power) and mechanical device with or without engine (mechanical power) [14]; [1].

Consequently from the above therefore, we can say that there are generally three (3) sources of power for farm agricultural work, and they are:

a. Human power
b. Tamed big size four (4) legged animals
c. Mechanical power

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Therefore, the authors are in agreement with [4] and [14]. But if according to the nature of the sources of power, we can group them into two (2), namely the **Biological being (animals)** and **Mechanical devices**:- The Biological group of animals is made up human beings (a higher class animal) and the other appropriate animals like horses and cattle most especially, and Donkey, Oxen, Carmel, etc.

The mechanical devices can be:-

(a) **force machines** (which are engines and motors) that are self-propelling and mechanical aggregates (which are compound formation of engines/motors with work implements and tools)

(b) non-force machine. The force machines are capable of burning fuel or converting electrical energy to create pressure/force that creates motion/movement in the form of mechanical drives [15].

The mechanical power group is subdivided as follows:

i. Machines without engine

- ❖ Machines with wind propeller (wind mills)
- ❖ Machines with water propeller (turbines)

ii. Machines with engine

- ❖ With heat engine:

1. Engines with internal combustion ***These are diesel engine like*** tractors, combine harvesters, etc. and petrol engines represented mainly by autocars and lorries for transport in agriculture.

2. Engines with external combustion for activation represented by steam engine tractors and machines (which have disappeared from great majority of the farms today).

3. With engine having electric motor (electric activation)

The Sources of Power for farm works can be grouped into two in accordance with the position taken in the course of execution of work, namely:

- ❖ Power for stationery works and
- ❖ power for mobile works

Stationary works are usually carried out within the house/farm house and outside the house/farm house. The principal sources of power for stationary in-house and around the house works are machines with electric motors and others are windmill, man and small size combustion engine fixed machines like grinder; winnower, maize Sheller, etc.

The major sources of power for mobile field works are engines with internal combustion and others are tamed big size four-legged animals and man [16]. Today, internal combustion engine is represented principally by tractors for cultivation operations and farm transport while lorries and autocars are

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employed for movement of goods and personnel.

Flowing from the above, it is therefore normal and expedient that in the mechanization of agricultural production right choices must be made for better management of the energy base (resources) [17]. The source of power used for the execution of any work depends on so many factors among which are the following:

a. The nature of the site/place where work is to be performed;

b. Type of work;

c. The magnitude and duration of work;

d. The economic efficiencies of the sources of power available

e. The availability or dispensability of alternatives sources of power;

f. Safety conditions availability/safety assurance;

g. The availability or otherwise of necessary skill and expertise;

h. Financial capability; etc.

Therefore, it has also emerged that the correct position is that there are various sources of energy for the force machines (engines/motors) used for farm work and they are as follows:-

According to [14] there are various sources of energy for the force machines used in carrying out farm operations and these include:

(a). **Fuel:** Which is chemical in nature and burnt by combustion engines.

(b). **Water Current:** Which is physical in nature and used for turning turbines

(c). **Wind Current:** Which is physical in nature and used for turning windmills.

(d). **Sunlight/heat Energy:** Which is both chemical and physical in nature and used for energizing solar cell equipment, direct heat drying (evaporation), etc.

(e). **Atoms and their nuclei:** Which are physic-chemical in nature

(f). **Electricity:** Which is physico-chemical in nature

These sources of energy for farm force machines have their own origin which can be:

- Natural e.g sunlight from the sun; water current from flowing streams, rivers, etc; wind current from wind mass; atoms from matter; coal.
- Synthetic e.g chemical fuel (petrol, diesel, kerosene, oils), electricity, etc.
- Mixed (natural-synthetic). This includes biological fuel e.g heat energy from burnt organic materials (wood, dried leaves and animal bones).

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A close study of agricultural development in relation to the energy ratio of manual labour and mechanized types of agriculture would reveal that **solar power has to be maximally used and there is the necessity for greater consumption of combustible fossils and electrical energy in order to increase agricultural production through mechanization and irrigation** [14]. The need for maximum use of solar energy is borne out of the need to protect the environment and conserve exhaustible sources of energy [18]. While the introduction of mechanization is synonymous with high consumption of energy, its advancement is synonymous with increased consumption of energy.

4.2.4 Tools/Implements, Simple Machines, Machines and Engines

A. Meaning of a machine:

According to [15] a machine is an assembly of elements/parts which are joined together in a tight interdependent relationship such that they form an entity made up of mechanisms and or organs which perform defined motion or movement to effect useful work. Machine can be simple or complex.

A machine is simple when it is made up of one or two (1-2) moveable joints. And examples are the lever mechanism, pulley mechanism, screw-jack mechanism and interlocking gears/wheels (directly or indirectly) mechanism. A complex machine is thus, made up of many simple machines.

B. Meaning of an engine:

An engine is an assembly of elements/parts which are joined together in a tight interdependent relationship such that they formed an entity made up of organs and mechanisms which convert energies (by burning/consuming energy material source) to exercise power or motion to perform **useful mechanical work** [15].

C. The co-relationship between machines and engines:

While all engines are machines, not all machines are engines. Distinguishably the engines perform useful mechanical work while machine effect useful work.

An important characteristics of machines in action or operation is that the magnitude and direction of force or pressure at the point the work is being done can usually be different from the value at the point of application depending on several factors (not part of this paper).

D. Meaning of tools/implement

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Tools are small or large **single piece** devices (hand tools) used to make work easy. They do not have any moving joint. Therefore, tools do work by direct strike, slash, push or pull, etc. the bigger tools which are not handy are referred to as mechanical implements and represent piece/part or assembly of pieces/parts used for mechanical processing of materials with aim of changing their forms, dimension, position or properties. They are used for carrying out farm work, such as soil tillage/ploughing, harrow, some type of cultivator, ridger, etc, and because they have bigger sizes they cannot be worked with manually while much smaller ones can be used for work with animal power source.

Agricultural implements and tools do not poses **motion transmission** organ between the power sources or from their rolling wheel/tyre and their working organs [1]. And this represents the major difference between engine power pulled/pushed large/big size agricultural implement and agricultural machines.

For tools/implements, work is done when they are moved by the person or mechanical power unit holding the tool/implement [19]. The work is done by the **force** the tool/implement makes directly on the object upon which work is being done. The size and direction of movement of the force that is applied are the same with which the tool/implement attacks the object being worked on. The work that is done is therefore equal to the energy consumed. Examples of hand tools for farm work are axe, cutlass, rake, spanner, hoe, shovel/spade, trowel, sickle, hammer and knife. In general hand tools are rigid single piece device.

E. Meaning of farm/agricultural installation

This represents an assembly of mechanical aggregates, apparatus, civil constructions, instruments and accessories which either facilitates the execution of some **operations** within a given production process or provides the necessary function/support for the carrying out of the process of production. Usually, installations bear the names of the works for which they serve e.g. irrigation installation, installation for seed processing, installation for wine production, drainage facilities/installation, etc.

F. Meaning of farm equipment

Agricultural/farm equipment represents an assembly of installations, mechanical aggregates, machines, engines apparatus, tools/implement and dispositive that

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are gathered together for use in the execution of a given technological process or some works within a process of production in the different sector of production in the agriculture. For example livestock equipment, harvesting equipment, etc.

G. Meaning of Mechanical aggregate

This represents a combination of tractor (as power source) and various agricultural machines and implements prepared for a particular type of work. It can be **simple** or **complex** depending on the number of operations or works to be done at one/single movement of the tractor. For example tractor plus plough is a **simple aggregate,** while tractor plus partial cultivation/tillage plus seeding plus application of herbicide and/or inorganic fertilizer is a **complex aggregate**.

4.2.5 Agricultural Engineering and Agricultural Mechanization

A. Meaning of Agricultural Engineering

Agricultural Engineering occupies itself with the designing, construction/fabrication, exploitation and management of facilities, made up of forces and materials of nature, which enhances scientific agricultural production. These includes machines, engines, farm structures (including livestock housing, irrigation and drainage installation, farm electrification, farm access roads etc).

B. Meaning of Agricultural Mechanization

Agricultural mechanization is basically the exploitation and management of machines, mechanical aggregates/installations in replacement of manual and draught animal works in agricultural production. In this way, it includes the efficient selection, operation, repair and maintenance and the replacement of machinery.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

It can be said that the sources of energy available in farms are electricity, water current, wind current, atoms, sun and chemical fuel burnt by heat engines (e.g petrol, diesel, vaporizing oil, gasoline, kerosene and animal bones, coal, etc).

It can be said that the sources of power for farm work are human beings (human power), **tamed big size four-legged animals** (animal power) and mechanical power (engine, machines and mechanical aggregates, etc).

The fact that tools (whether of metal or non-metal materials) makes work ease to be done does not make **tools** to be called **machines**. Their working mechanisms differ greatly. Tools have no moving joints that can change

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the magnitude and/or direction of force between the point of application and the point work is done unlike the case of machines.

That a machine is simple because of having only one or two (1-2) moving joints does not make it to be less a machine. Therefore, a machine is a machine whether simple or complex, small or big. While all engines are machines, all machines are not engines.

Arising from the above therefore, this paper is apt and deserves academic attention and discourse. It would promote knowledge in agricultural engineering and agricultural mechanization that will enable agricultural production development strategists, specialists, agencies, parastatals, etc have the right concept.

5.2 Recommendation

i. The corrections should be brought to the attention or awareness of the authors and publishers of Basic and Secondary Education levels textbooks of Science and Technology, Agriculture/Agricultural Science and vocational studies in Nigeria.

ii. The authorities of West African Examination Council, National Examination Council and National Business and Technical Examination Board should through their established media bring these errors and corrections to the attention of their examiners, of which majority are teachers and instructors/lectures in all levels of Education.

The authorities of government agencies in charge of education planning, management and standard should take necessary steps to correctly review their curricula.

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