Integrating the Natural and Social Sciences in a Ghanaian University: An Idea for Curriculum Orientation

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Abstract

The time has come for the natural and social scientists to integrate their disciplines for the acquisition of skills to solve real life challenges. This study was premised on the belief that the principles of systems thinking, humanitarianism, sustainability, security, and love, which feature prominently in the social sciences could be integrated into the natural sciences. The underlying theory for a possible approach was considered to be the social constructivist theory, as it could transform learners' ideas about the intersection of natural and social sciences in an active, motivating, collaborative, and non-discriminatory manner. An instrument used to gather data on this idea was a semi-structured guided conversation. Data gathered was interpreted qualitatively. Findings showed that the process to transform the teaching of natural and social sciences was feasible to enable learners to acquire transferrable and concept skills for lifelong living. Participants became aware of the possibility of applying scientific knowledge to solve some humanitarian challenges. They observed that the integration would enable the development of attributes such as love for each other and the environment, tolerance, patience, critical thinking, reflective and analytical skills, if the proposition is considered for curricula implementation. The conversations corroborated findings from other studies that perceived that science integrated in the social sciences and vice versa was feasible. It was concluded that, exposing Ghanaian students to real life experiences in a safe environment through chemical and social principles could make them appreciate the chemistry concepts in the social sciences, and vice versa, for a better world.

1. Introduction

The world is fraught with challenges in many areas such as poverty, hunger, inequity in the sharing of resources, poor water and sanitation, insecurity, wars and many more. Education has been touted as a key to economic growth, health and security [1]. Has this assertion proved true before and now? Will it prove true in the future? Many questions come to mind as one considers the assertion that education as a major pathway to a better life in a better world [2].

The two major divides in education are the humanities and natural sciences The humanities, which will be considered under the umbrella of social sciences in this study will envision disciplines such as cultural studies, economics, political science, sociology, history, social studies, geography, citizenship studies, civics, music, psychology, family life, anthropology, and political science; just to name a few. Social sciences and its study deal with human beings by studying their behaviour, growth and development, relationships, resources that they use, and the various institutions they require to function and carry on their lives. In other words, it deals with relationships within a society and how the organs interact. Social Studies (an aspect of social science), which is a basic subject through grade school, is incorporated in the school curriculum through a combination of subjects like History, Geography, Cultural Studies, Economics, Political Science, Sociology, Psychology, Anthropology, etc. In the social sciences, human agents are seen to work in concert to fulfil intentions per local rules, customs and cultures. Pedagogies such as story-telling, supervised study, text book method and lecture are employed.

On the other hand, natural science, which is a branch of knowledge that deals with the physical world, is methodical in approach as it goes through experimentation in a cold objective manner; not paying any attention to mysteries as observed in the social sciences, because it seeks to understand natural phenomena, as observed. Natural science is incorporated in the school curriculum through subjects like astronomy, biology, chemistry, physics, integrated science, chemical toxicology, and biochemistry and pedagogies for teaching science has been basically activity-based, with students performing experiments to confirm or refute existing theories [3]. Recently, more emphasis is placed on inquiry-based and problem-solving approaches in teaching integrated lifelong programmes of which an amalgamated natural-social science curricula will be no exception; if implemented.

Students often perceive that learning about natural science, especially chemistry, is all about knowledge

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of chemical elements, fundamental concepts, and the conduct of laboratory exercises that border on confirmation of discoveries made by earlier scientists. Years of personal interactions with students has shown that they often find the transfer of fundamental scientific knowledge to broader topics and real life experiences a challenge. They often ask the question, 'what is the essence of studying this principle? How could this theory be applied in real life?'. Yet, all learning is a social product; a move towards economic freedom, security, peace, humanitarianism, and a more sustainable world [4]. Solving real-world problems requires bringing together insights from multiple disciplines [2]. This educational goal represents a concern for teaching and learning the natural sciences in general, and chemistry in particular [5].

The study of every kind of discipline, including chemistry from the natural sciences, must be geared towards creating an individual who can live in a society and be lived with. Besides the capacity to accommodate and tolerate others and be accommodated by others (tolerance and concern), one must be capable of understanding the environment and harnessing resources for the well-being of one's self and that of others through holistic education. A few studies [6, 7] have considered integration between the social sciences and ecology from the social sciences, but not chemistry in particular and the natural sciences.

The current UN goals for education which are towards sustainability, humanitarianism and attainment of Agenda 2030, adopt holistic education principles that could become a meaningful guide for chemistry learning beyond the laboratory [8]. Contemporary education must foster a sense of collaboration and a sense of responsibility towards active contribution to sustainable living. This implies that the content of a new chemistry curriculum (the social science curriculum also implied here) must be geared towards desired values and world views. The curriculum must be holistic and pedagogies student-centred so as to provide information that could inform wise decisions about world issues like energy, climate, culture, food security and health, to name a few. Most higher education curricula are still dominated by the mechanistic paradigm and would require a shift towards multidisciplinary, contextual, ecological and humanitarian paradigms [1, 9]. Various step wise approaches would be required for proper engagement and execution. Here, the consideration of critical steps must encompass a formal analysis of the integration, characterising how the major players (being teachers, learners, and experts) would connect with the space in which they find themselves, their behaviours and finally the intervention of a new informed curricula. This would be the formal analysis of the situation that would allow for integration. Each stage would require collaboration with experts as well as continued engagement.

The integration of natural and social science could be important in disciplines such as human transport, urban geography, human geography, and in atmospheric physics, ecology, environmental chemistry, ocean/marine science as well as environmental science, where scientific principles are applied among people and infrastructure. This is because local rules and principles are upheld for citizens' comfort, well-being and security. In this wise, there is a possibility that integration of the natural and social sciences would move towards the attainment of security, sustainability-literate individuals, humanitarianism, and ultimately a realistic attainment of United Nation's Agenda 2030. There must, therefore, be a possible route to attain this integration which could result in love and respect for each other, dignity of humans, peace, increase in economic and social indices, humanitarian issues as well as proper management of the world's resources. Developing citizens to create the aforementioned society or community, actually defines the objective of schooling [10].

Humanitarianism, as applied in this study, is an active belief in the value of human life, whereby the practice of benevolent treatment and provision of assistance to other humans to reduce suffering and improve the conditions of humanity for moral, emotional and altruistic reasons is prime. Sustainability is a construct that often refers to a concern for intergenerational equity [6, 4]. Sustainability deals more with the interconnectedness among its three pillars- environment, economy and society.

It must be noted that the terms 'sustainability' and 'sustainable development' represent different ideas, though some authors use them interchangeably. Sustainable development is a pattern of resource use that aims to meet human needs while preserving the natural environment so that these needs can be met not only in the present, but in the indefinite future, as enshrined in social science and green chemistry principles. The term, sustainable development, was used by the Brundtland commission which coined what has become the most often-quoted definition, as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" [11]. If we must, through education, ensure sustainability and humanitarianism for a peaceful and fruitful world, then our focus in the integration of the social and natural sciences must not be only on sustainability and humanitarianism as stand-alone disciplines, but on systems thinking as well. It will be easier on both the natural and social sciences if both divides view the earth's space as a system so that its mechanisms and all that has to do with its understanding is made possible through holistic teaching approaches.

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Meaningful learning requires learners to integrate ideas across different content areas of study rather than fragmentations of what they learn into discrete units of knowledge. Research shows that students in integrated programmes show better academic performance than students in discipline-based programmes [12]. This finding supports the current study which advocates for the integration of the natural and social sciences.

Systems thinking, as applied in both natural and social science, as well as this study, is a way of making sense of the complexity of the world by looking at it in terms of wholes and relationships rather than by splitting it down into its parts. It has been used as a way of exploring and developing effective action in complex contexts [13]. Systems thinking draws on and contributes to systems theory and the system sciences. It is a holistic way to investigate factors and interactions that could contribute to a possible outcome. This idea of 'holistic approach' which falls within 'systems theory' would suit the intention and pathway for integrating the natural and social sciences and help to attain the 2030 global goals that address poverty, hunger, shortfalls in housing, education, sanitation, energy supply, peace, and many more. Thinking of the sustainability of the planet earth as a system was part of the motivation for the promotion of the integration of the natural and social sciences.

2. Any distinct differences to be expected between the 'two divides' of sciences?

From the empiricist or positivist view, natural science produces legitimate knowledge but in the social sciences, human agents work in concert to fulfil intentions and achieve activities per local rules and customs. Solutions to difficult problems at the interface of the environment and human society require the synthesis of diverse types of information from natural and social sciences. Learners must develop the knowledge, skills, and abilities that allow them to undertake such synthesis efforts and successfully engage in interdisciplinary hard work to solve socio-environmental problems.

2.1. Possible integration pathway

It is proposed that the research design must begin with careful discussion about the intended concepts in curricula and efforts that must be applied during the research so that all members in the design exercise can use a model which will theoretically integrate both social and natural intricacies. The qualities and needs of both fields would have to be catered for so that people would have confidence identities of their disciplines would not be belittled, appropriated, or overwhelmed by the integration or accommodation. The creation of the need for the application of different disciplines in a project could be a sure way out to this realisation of the intended integration of the natural and the social sciences.

In the University of Education, Winneba, it was found that both the Faculties of Natural and Social Sciences had a common subject of study-Environmental Science. How were these disciplines designed to be offered at the two currently distinct faculties such that they cannot be seen as a common course of study, where students from both divides of the sciences could comfortably sit in a joint class?

3. Execution of the integration of natural and social sciences

Several courses of study offer educators who are interested in bridging the gap between the two divides of the sciences a point of departure from the old path. Some of these, from literature reviews, were found to be ecological economics, social ecology, and environmental law. What must be recognised and treated with caution is the fact that mutual respect and the knowledge that each participant is indispensable in such a project of integration must be high.

Topics that lend themselves to both sciences must be considered to avoid translation and teaching constraints, but more importantly be designed for holistic teaching. The themes should help learners to make sense of their world and identify their roles in it. Elements that must be consciously incorporated during the design and implementation of the integration should be chemical ecological components, socio-cultural components, and economic components. All the 17 goals of the UN Agenda 2030 are already embedded in these three pillars for the integration, though implicitly for some. A proposed framework that could aid the understanding and execution of a possible integration, was discussed among interested researchers who were happy to forge an integration between the natural (chemistry in particular) and social sciences. The topic on 'water' was chosen in this study for the development of a prototype integrated lesson. This idea to study a topic on water came up as it was identified as one topic that transcended many disciplines and could be a good starting point for cross-disciplinary studies. Indigenous topics for both sciences were considered, after which integrated topics for lessons and teaching approaches were considered. A sample of indigenous or native topics from the natural and social sciences and their integrated topics are shown in Table 1.

Other integrating disciplines that could have been considered could have been Public Policy and Environmental Science, to result in a course of study such as Integrated Environmental Management;

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Table 1. A sample of an integrated natural-social science plan on water as a system

Natural science topics	**Social science topics**	**Integrated lesson**	**Integration strategies**
Sources of water	Sources of water	Sources of water	1. Story in a reflective/analytical form i. Water is vital for human existence. We will analyse the nature of water, its availability, usefulness (especially for fresh water), and purification processes ii. Let us assess the cost of purifying identified polluted water as well as the effect of the polluted water and cost of purification on community members and the nation as a whole in small groups. iii. Identify existing policies that could protect inhabitants or otherwise and their implications. iv. Case study: How are sustainability and humanitarian issues catered for in national or local policies? v. Let's have a whole class conversation on the question: How would natural chemicals from natural waters affect ocean circulation, ecosystems and human activities?
Properties of water	Uses of water	Nature of water	
Hydrogen bonding	Water and human communities	Contaminants in water	
Water cycle	Water distribution	Water cycle	
Pollution	Water pollution	Conservation of water	
Purification of water	Clean water	Human health and water distribution on surface	
Uses of water	Policies on water production	Policies on water production and use	
	Right to water use	Policies on water use	
	Ocean circulation and ocean currents	Life in the ocean	

native Economics and Conservation Biology to yield Conservation Economics; while Tourism and Hospitality and Natural Resource Management could amalgamate to give 'Sustainable tourism'.

3.1. Trustworthiness of data gathered

To ensure that appropriate data was gathered for analysis, participants with diverse perspectives were purposively included in the deliberations on the proposal to integrate the natural and social sciences. This was to enable the capture of multiple realities of the subject of interest. In this wise, the approach employed in gathering data (guided conversation) was tailored towards the integration and prolonged until data saturation was arrived at. This was followed by peer-debriefing, member checks and a deliberation to find out if findings gathered by us could be transferred to other similar groups, situations, and content, regardless of demography. Besides these, an audit trail was conducted, to be sure that another researcher could follow the 'decision trail' employed. Furthermore, the data was scrutinised severally, alongside its outcome to be sure that one would find the conclusion to the study grounded in gathered data. All of these processes were to ensure credibility, transferability, dependability and confirmability of the research process and its outcomes.

4. Matters arising from discussions on proposed integration and sample integrated plan

It was obvious during discussions that researchers from the two divides of the sciences, natural and social science, still held on to specialties in their individual fields in the beginning, yet tried to maintain a balance in how an integrated approach to teaching should be forged. A few with diverse views observed that:

Natural and social scientists in truth have different assumptions. How could both be incorporated on a similar basis?
Of course, as we are scientists, we must always do something nouvelle so we are doing exactly that; like cloning, genetic modification or something of a sort in education.

The above assertion met a gentle rebuff with the statement:

Our environment must not only be seen physically as our natural scientists do, nor socially as we the social scientists do, but in a biophysical or socio-physical manner with everything one can conceive included; it is difficult but achievable.

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The gentle rebuff could mean that there was a chance to embrace the integration and perhaps look at reorienting individuals towards the change [3, 12]. It was agreed upon that the integration of the natural and social sciences should be carried out in as many topics as would lend themselves to it, if they had similar concepts that cut across them, because it would enhance collaboration between learners, teachers, and researchers. This was one assertion:

I am sure that if we can work effectively as one body with as little distinction as possible of our individual fields, we will understand each other better and work in a more coordinated approach to solve social or national problems; not just solve problems but be proactive in developing a better world, moving forward.

It was also clear that further research would be necessary to develop a realistic understanding of how students would process understanding in the integrated curriculum so as to develop pedagogies that teachers would use to facilitate students' understanding and appreciation of their environment from an integrated stance. This would call for integration of knowledge to develop theoretical frameworks that would ensure the development of critical thinking, reflective and analytical skills [10]. A statement in support of this category of thought was:

Education is to enable learners to be critical thinkers. The proposed course plan on water clearly shows not only how learners will collaborate to work on projects to develop tolerance and collaborative skills but also how they can think critically as they design solutions to real life problems in communities in which they live, but analyse the situations before they embark on solutions and then reflect afterwards on their actions. These skills that we have identified must be built into a framework that would guide the integration.

It was noted that a teacher who lacked competent content knowledge about a discipline that was not his original discipline studied in school would often resort to lecture the integrated topic instead of using learner centred teaching techniques that produce real student understanding, so as to cover up short coming [9]. This is what one participant noted:

If I do not know much about chemistry or any of the natural sciences, then I cannot teach the chemical nature of water or ask students to do projects which portions involve pure science, as I cannot assess them effectively for student understanding. In teaching about natural science aspects, I will use book lecture or skip parts of the curriculum.

A participant agreed with the noted assertion and added that a teacher who had complete control over content knowledge would most likely be able to choose best teaching and learning approaches to achieve his objective [7, 14].

Yes, knowledge in a subject or topic helps one to execute or implement lessons with understanding or much ease, as well as support one's learners to also gain understanding and acquire the necessary expertise.

Henze, Van Driel and Verloop [14] claim that teachers' knowledge, determines to a large extent, how they respond to educational innovation.

Another category that most participants tended to make similar observations over or agreed upon was the fact that the merger or integration of the two sciences could lead to abetter understanding of the world, lead to peace and security, better housing, and bring about a more proactive handling of many existing challenges (which solution has been 'one-sided) if knowledge from each divide of the sciences could be brought to bear when solving problems. For example, one social science participant intimated that:

When we have to assess best materials or resources for better and durable housing for communities, the natural science people can come in with their engineering and tell about durable metals and soils as well as other things that can be used to build cheaper but affordable houses. Our people need houses to live in but cannot afford it, leading to housing insecurity.

In Matlin, Krief, Hopf and Mehta's [1] findings from their publication titled 'Re-imagining priorities for chemistry: A central science for freedom from fear and want', they look at the import roles that chemistry education can play in ensuring sustainability of the world's resources, ensure security in diverse aspects and bring about peace. The things that they talk about in their publication is no different from what social scientist strive to achieve. This suggests that, indeed, there could be an integration of the two sciences-natural science and social science. Hardly would one have expected chemists to be talking about food security, poverty and other humanitarian challenges and how they could be solved in a pragmatic manner from the scientist's point of view.

It was identified during the discussions by participants in this current study that the integration of the natural and social sciences had begun in some regions outside of Africa. In a Global Change Research Programme report from one of the meetings on integration of the sciences, four key areas were proposed for inclusion in an integrated programme. These areas were the social elements that were most related to the climatic, biogeochemical, and biological drivers of change. The areas designated were (i)

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global land use change, (ii) industrial metabolism, (iii) usable knowledge of global change, and (iv) institutions for management [7]. This Global Change meeting particularly looked at integration between economics and ecology as other similar meetings had done. It is reiterated that in Africa, and Ghana in particular, literature on such important integration of disciplines on different divides was not found; at least at the time of this research deliberations.

5. Conclusion

Researchers in this study unanimously agreed that the integration of the natural and social sciences was laudable for sustainability, peace, security and better protection of the world's dwindling resources and must be pursued. It was further observed that good protype lessons that show overlaps between the two sciences should be used to initiate the integration. These overlaps must show combination of views that meet on a common ground in the interest of issues like sustainability of the world's natural resources, identification of best materials for construction (as in housing), food production, healthier environments and such issues of human concern. Teachers' knowledge base in the natural and social sciences must be developed so that teachers who dealt with single disciplines would be competent in handling topics from multidisciplinary and not just interdisciplinary points of views. Requisite pedagogies must be developed along with equipping teachers with the needed knowledge to facilitate a change since benefits to be gained from the integration could be enormous. The environment must be seen as a construct from the perspective of the two sciences so that the developed pedagogies could portray shared concern and tolerance. It is hoped that the integration would equip learners with lifelong skills, sustainable and humanitarian principles so as to ensure financial sustainability in the end, promote healthy ecosystems, and develop critical thinking skills to transform learning and subsequently, the world [15].

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