PERCEPTIONS ABOUT A STEM-BASED CURRICULUM: A PHENOMENOGRAPHIC APPROACH

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The Great World Challenges

The world is facing major challenges that are likely to affect our personal and professional lives:

INTRODUCTION

- Science Technology Engineering and Mathematics (STEM) is an approach to learning and development that integrates disciplines for development of skills such as critical thinking, creativity, critical analysis, teamwork, independent thinking, initiative and digital literacy, creating next generation of innovators
- It has the capacity to cause a change in global economy as recent automations cancel regular jobs
- Employers also demand STEM qualified candidates
- It affects continuous advances in technology and the way students learn
- Relevant curriculum must therefore be relevant and forward looking to ensure learners gain skills for tomorrow's economy

INTRODUCTION

- STEM plays a concerted role in sustainable development of societies (Moore, et al., 2014)
- About 47% of today's jobs require technological application from STEM (Frey & Osborne, 2017). However, literature indicates that less than the required percentage qualify for these jobs (Sommet & Kekelis, 2016; Fayer, et al., 2017; Sias, et al., 2017)
- The anticipated science careers for sustainability have led to a demand in the holistic approach teaching of STEM
- The 2030 Agenda for sustainable development also sees STEM as the gateway for a prosperous, sustainable lifestyle and planet

INTRODUCTION-CONT'D

- STEM has no universal definition. It is an acronym.
- It is a curriculum based on the idea of educating students in four disciplines - science, technology, engineering and mathematics - in an interdisciplinary and applied approach for sustainability and systems thinking (Mahaffey, et al., 2019)
- It is a key driver of quality education and outlet to relevant learning processes and outcomes
- It nurtures creativity, collaboration and problem-solving skills for lifelong living (York, et al., 2019)
- STEM is necessary for economic growth.
- One of its tenets focuses on hands-on in real world settings

STUDIES ON STUDENTS' STEM PERSPECTIVES

- Studies have been carried out by Baran, et.al. (2016), Roberts, et al. (2018), Verdin et al. (2018) and York et al. (2019).
- These studies dwelt on the effect of STEM on cognition, how it impacted specifically on in-school math and science classes, the ontological beliefs of students in describing STEM personalities, how STEM influenced role identities, and how it influenced 'systems thinking'.
- Students' perspectives were found to be mainly on the fun side of STEM and the provision of an environment for hands-on activities

CURRENT STATE OF STEM IN GHANA

- Promotion of STEM began in 1987 through STEM Clinics but has challenges

  Gender stereotyping;

  Inadequate awareness of STEM;

  Policy guidelines;

  Funding
- Led to creation of Science Education Unit
- More hands-on activities

STATE OF AFFAIRS

- **STEM** is recently being taught as an individual (unidisciplinary)study and not in an integrated form (Hanson, 2020) that would yield the desired result of having a holistic curriculum for contemporary times education
- Disconnect between school science and industry
- Gender stereotyping
- Inadequate funding
- Poorly trained teachers

STATE OF AFFAIRS

- A cursory study of more than 50% of programmes run in the researchers' university and the curriculum for secondary and basic education indicate that STEM is not integrated into current educational programmes at all levels

- As at the time of gathering data for this study, there was no national plan to integrate STEM into the curriculum or to find out views from learners who had gone through integrated STEM studies

NEW DEVELOPMNT IN GHANA

- Infrastructure to begin a revised free STEM programme
- Learners to be trained in STEM from grade 6 to 12 in robotics, lab tech, artefact creation, mammal surgery etc.
- Develop 21st Century skills to affect personal empowerment, active citizenship and economic growth

GAP

- The expansiveness or otherwise of the identified perceptions in a related hierarchical state and their incorporation into the design of STEM curriculum (based on importance) were not identified in previous and current issues nor in literature reviewed by the researcher

PURPOSE OF THE STUDY

- Conduct a baseline study on the perceptions of students who had engaged in integrated STEM studies
- Contribute acquired findings on students' perceptions about integrated STEM studies to the world pool of knowledge on STEM
- Disseminate findings on how educators and curriculum designers could fit the findings into their teaching and national STEM development plans, respectively

SOME TERMS TO NOTE

- **Perception** connotes a process in which a person is aware of objects and events in their world as they go through the events of stimulation, organization, interpretation, evaluation and memory/recall
- Perception is a physical, physiological and psychological process
- It is the awareness, comprehension or understanding of something and is marked by three (3) elements: motivational state, emotional state and experience (Critcher & Gilorich, 2010)
- **Phenomenography** is a qualitative research method within the interpretivist paradigm that investigates different ways in which people experience something in a relational manner. It is basically subjective. Experiences are based on the relation between a person and their world

SOME TERMS TO NOTE

- **Outcome space** describes how students' perspectives are related and fit into an experience as a whole (Marton, 1994)
- It is often expressed graphically

OBJECTIVES

- To find out the different ways in which students perceive STEM lessons and projects

- To order identified perceptions in order of importance for possible integration into STEM lessons, projects and curricula

RESEARCH QUESTIONS

- What are the different ways in which students perceive STEM lessons and projects?

- How could identified perceptions be arranged in order of importance for integration into STEM lessons and projects?

THEORETICAL FRAMEWORK

- Theories on perception directed by phenomenographic approach
- Principles that guide the theory are that perception is relative and not absolute. It is selective and differs from one person to another though environmental conditions may be the same (Critcher & Gilorich, 2010)

- The phenomenographic framework was suited to the study as the main objective was to use students' varied perspectives to create a collective meaning in an outcome space that would contribute to existing knowledge and to build appropriate STEM curriculum

GUIDING PRINCIPLE CONT'D

- The phenomenographic assumption is that:

There are no right or wrong answers of a phenomenon as research is not interested in 'real; but how a person conceptualizes a phenomenon

- The three principles are:

- Categories should be extracted from responses

- Categories should not be mutually exclusive or inclusive, but distinguishable

- Responses must be explicit to be capable of categorisation

METHODOLOGY

- A phenomenographic qualitative approach (Marton, 1986) that employed purposeful sampling to drive desired objectives was employed
- Population was all students who had participated in a phenomenological study
- Sample was 13 students (7 girls and 6 boys); a little over 10% of a representation of a larger sample for qualitative studies (van Dalen, 1979)
- Data collection instrument: Guided conversation (between 8 to 22 minutes)
- Data saturation and trustworthiness ensured
- Ethical considerations ensured

METHODOLOGY CONT'D

- Two rounds of debriefing to establish consistency, dependability and credibility of the coding system and Two non-researchers served as analytical audience (Burrow, et al., 2017) for the purposes of credibility
- Applicability of methods and results (transferability) was ensured with thick descriptions
- Dependability ensured with consistency of responses from sample until data saturation (which could be same if activity were repeated)
- Biases minimised as findings were not affected by personal interests. Informal Field notes
- Analysis of data with Nvivo 12 for Mac
- Students' perspectives considered important inputs (products)

EXAMPLES OF CONVERSATION GUIDE

- What does STEM mean to you?
- What would you like to be when you grow up?
- Can you tell me about your experiences in specific topics and projects that you undertook in your recent STEM project?
- What were some of your difficult and fascinating experiences?
- Describe some of the inventive things that happened in the STEM project and their effect on your intended future career.
- How did the project contribute to your learning?

EXAMPLES OF CONVERSATION GUIDE

- Did the projects relate concepts in class/lab to things in the home or community?
- How does STEM relate to other discipline?
- What effect/impact did your project have on the environment?
- What do you think about this new method of teaching science that has bits of different disciplines integrated into a unit; as if it were a 'whole' system?
- How has the new method affected your perceptions about science, science careers and STEM in general? Kindly give an overview.

RESULTS

- Some responses to **question 1**

STEM is doing science or Math in a new way; connecting them more.

It is integrating Math into practical science

It is practical science and technology

- Some responses to question on their future career **(question 2)**

To be a STEM teacher and not just a Math or science teacher.

You see, the STEM does it all and students see how science and math work together in unison. It is perfect to combine the subjects like that for understanding… you apply all to solve same or given problem faster and realise that each subject bear on the other". (multidisciplinary),

To be an architect as I love math and design activities ….

To be an engineer because I like the physics and math part of projects

Pharmacist; I will learn about human beings and how to administer hospital or traditional medicine properly to heal the sick: not a doctor, really

SUMMARY OF RESULTS

Students' perspectives (categories)	Focus
Multidisciplinary	Acknowledging usefulness of STEM's interdisciplinary nature
Researcher	Applying acquired skills to gather data, interpret, analyse, find patterns, and arrive at conclusions
Content mastery	Building and deepening content knowledge
Skill developer	Developing and practising necessary STEM skills for lifelong learning
Career-oriented	Understanding importance and application of STEM skills for future careers & economic independence
Collaboration	Interacting on a higher level to augument purposeful learning
Real-life practice	Applying 'school science' to 'out-of-school' or 'real-world' situations through hands-on and minds-on activities
Problem solving	Developing innovative and pragmatic approaches to challenges/new situations
Socialisation Explorer	Social interaction for fun Exploring the unknown in STEM

EXAMPLE OF MULTIDISCIPLINARY

- The STEM combines all the different sciences, technical drawing and math and so it is like a one-stop or one-shot subject …. Or teaching that employs everything…. Here you learn everything in one lesson, even though the lessons are longer. But ma, it is better than like physics alone or chemistry (chuckles). Math is a challenge but I get help from my group

EXAMPLE OF CONTENT MASTERY PERSPECTIVE

- The activities were intricate and cut across many subjects that we know……like math hands-on activities, chemistry practical activities, biology activities…..and engineering. We actually needed all these concepts from different subjects to complete our project.
- I loved the ‘out of class’ science in the community and relatives saw us as real scientists. Parents think it is prestigious to read science so I loved that my community saw me. It made me learn harder to understand better and will strive hard to be a great engineer to build modern roads and bridges … with some new materials that will come up.
- We actually needed to always learn different concepts from different subjects to complete projects

EXAMPLE OF SKILL DEVELOPER PERSPECTIVE

- We engaged in more real activities than ever before in areas like math and physics where we hardly did activities. Sometimes we improvised some of our materials for projects and they also worked like what we find in books. I got to build my confidence level with regards to using the scientific instruments too….

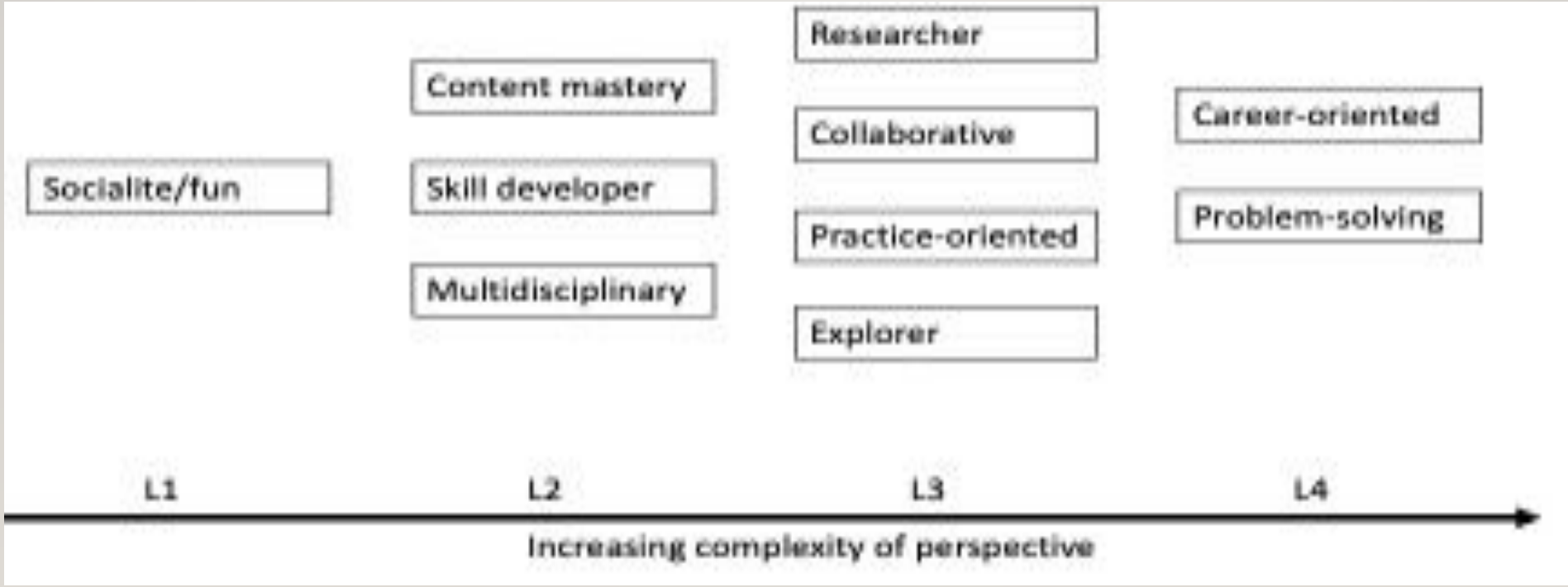
- I love to build things like planes, trains, some toys for play, but I never knew that I had to do a bit of chemistry….like, knowing about the kinds of useful materials and their types….properties and the best ones to use for efficiency. See, with the Ship project, we had revised properties of matter in our group, work on alloys, weigh, measure…put the manufactured toy in water and think of density, then the real field work was full of activities and great. I felt like a proper scientist

NOTES FROM STUDENTS' PERCEPTIONS

- The flexible learning space was observed to impact positively on the students, who alluded their interest and success with activities to the highly engaging in- and out-of class activities
- Contextualised learning and high engaging activities led to the development of cognitive, social and affective skills
- Professional identities were developed
- Everyday school lessons must be multidisciplinary
- Perspectives were arranged with respect to the depth of coverage (importance).
- Higher levels were assumed to portray broader views of STEM while those on lower levels showed limited coverage.

DEVELOPMENT OF THE OUTCOME SPACE

An outcome space based upon identified levels of STEM perspectives is shown as Figure 1



INTERPRETATION FOR DESIGNATED LEVELS

- Level 1: No commitment to explore or achieve the objectives of STEM
- Level 2: Complex; Focus on notable goals of STEM, but no mention of the use of skills as interconnected or of use in real world
- Level 3: Sophisticated; more aligned with objectives of STEM; include integration and application of knowledge for life
- Level 4: Encompassing; spells out implied/ultimate aims of STEM and beyond; interventive and innovative skills leading to STEM-related careers for sustainability and economic growth (Hetty's/ Roy's comment)

CONCLUSION

- The way in which students perceive STEM could affect what and how they gain from STEM-integrated lessons.
- Participants perceived that they developed deeper intellectual, collaborative and STEM-career oriented ideas, though a few were found to enjoy the fun side only
- Though all 10 identified perspectives must inform the design of STEM curricula to improve STEM learning and outcomes in a holistic manner, the higher levels must be considered more favourably as it could lead to an improvement towards building capacity for STEM related occupations

IMPLICATION

- STEM studies are important as they could contribute towards advancing STEM education research and practice

THE WAY FORWARD

- Provide infrastructure, equipment and reforms
- Address disconnect between theory and practice
- Integrate more real life issues into curricula
- Enhance quality of science teaching to strengthen STEM knowledge and skills
- Enhance practical problem-solving activities
- Promote experiential learning towards development of entrepreneurial skills
- Focus on assessment of gained skills

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THANK YOU