**EXTENDING GEOMETRICAL THINKING FOR EDUCATION IN SITUATIONS OF CRISIS**

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**Abstract**

*In this paper, the application of Mathematics in the Ethiopian current socio-political scenario is sought. The research can be aligned to the socio-political dimension of mathematics education. In this regard, Situational Analysis is employed as a method of inquiry in order to investigate issues like: how can an education in situations of crisis be strategically planned? Among the values of Mathematics is problem solving. Let us pose this: since Ethiopia’s plateaus had contributed to the inception of Geometry in the antiquity, what does Geometry contribute to Ethiopia’s socio-economic challenges? Desk review was mainly employed for gathering information. Taking an Ubuntu paradigm, a topological viewpoint and geometrical perspectives are sought to reveal durable solutions. The education system has to give opportunities for students to develop these perspectives and apply such methods.*

***Keywords:*** Creative thinking, Education in emergency, Geometry, Topology

1. **INTRODUCTION**

Although Ethiopia has been investing inputs in the Education sector, positive impacts on the socio-economic scenario of the country are invisible. Rather, internal conflicts, rising levels of food insecurity and climate-related problems are continuing to have a significant impact on children's access to education. Thus, the pursuits for equity and quality are seemingly not secured. For instance, horrible national assessment reports on early grade reading and Mathematics, secondary school leaving certification and graduate admission test are being disclosed. As a result, the quality of education is under question.

The Government has been showing commitment to ensure access to education by refugee and host communities ([MoE, 2021b](#_ENREF_21)). In cases, where schools operate in areas at risk from emergencies, it is expected to serve with standard ‘emergency’ teaching and learning ([MoE, 2021a](#_ENREF_20)). **In a sense**, “risks” are integral to the education sector. Restoring education may be sought by people in a situation of conflict, violence, (natural) disaster, cause of flood or drought and pandemic disease. These, in turn, might result in migration and internal displacement.

In this regard, the dynamic mobility condition may demand concerned bodies to look for a proactive and flexible education system. In line with such an issue, two basic questions are posed which could call for well thought strategies and recommendations.

*Question 1: How is it possible to eradicate or minimize emergencies?*

*Question 2: How can education in situations of crisis be strategically planned?*

This paper is intended to reflect on contemporary education and training practices in Ethiopia from Mathematics point of view. Thus, I tend to rely on ‘mathematics education’ in the socio-economic and cultural contexts ([Bethell, 2016](#_ENREF_4)). In a sense, it goes in line with the socio-political dimension of mathematics education research.

1. **METHOD**

I understood that a Situational Analysis can fit with the issue under study as a method of inquiry. There are two interrelated viewpoints of “Situational Analysis”:

1. analyses of strength, weakness, opportunity, and threat; and
2. maps of “the situation” as the key unit of analysis by considering major human, nonhuman, discursive, historical, symbolic, cultural, political, and other elements ([Clarke, Friese, & Washburn, 2018](#_ENREF_6)).

The current research is based on the second viewpoint of Situational Analysis. It considers views in a context where different groups of people are affiliated to some identities ([Clarke et al, 2018](#_ENREF_6)). As an extension of Grounded Theory, it is about research based on analytical work and memos of various kinds. It is basically based on the principle that situations become the fundamental units of analysis. It generally focuses on understanding relationalities among heterogeneous elements, social worlds, and debates in situations and their ecologies. Thus, I consider that meanings are derived from social interaction and modified through interpretation by analyzing situatedness, variations, differences of all kinds, positionality and relationality in their complexities, multiplicities, instabilities, and contradictions.

1. **RESULTS AND DISCUSSION**

This section has two parts: results and discussions. The first part is organized by four themes: contexts, philosophies of Education in Africa, Education and Training in situations of crisis, and Mathematical views. The fourth theme covers the topological viewpoint and geometrical Perspective. On the other hand, the second part, Discussions, addresses two themes: creative thinking and out of school program.

* 1. **Results**

One of the goals of United Nations’ (UN) agenda 2030 is “ensuring inclusive and equitable quality education and promote lifelong learning opportunities for all”. On the other hand, “Education in situations of emergency and crisis” is one of the issues of “Education for All”.

**Contexts**

It is noted in the current Education Sector Development Plan (ESDP VI) of Ethiopia document that a cross-cutting program on education in emergencies (EiE) would ensure a rapid response to circumstances arising from the emergency. Such self-initiatives could make great contributions to sustaining development. In line with such a point of view, Adwa Pan African University was assumed to serve the continent from the inside. Yet, the area where the institute was supposed to be built or established is currently in Chaos. By its very nature, *Education in Emergency* (EiE) is dynamic, sensitive, and has the possibility of unpredictability (Ethiopia Education Cluster, 2021). It seems that EiE is a concern of various organizations inclusive of those who deliver aid or relief.

**Philosophies of Education in Africa: Equity and Inclusion**

In quest of attaining ubuntu justice, the healing of scars, prevention of violence, mediation of crises, and enactment of equality, freedom, inclusion and responsibility become necessary ([Waghid, Waghid, & Waghid, 2018](#_ENREF_38)). Ubuntu holds humanness as critical to human development into its systems, particularly, its formal education systems ([Takyi-Amoako & Assié-Lumumba, 2018](#_ENREF_34)). Thus, Ubuntu justice offers an African philosophy of education a distinctive feature in that such an understanding of education has non-violent, moral and restorative purposes that could be attained if Africans practice equality, compassion and reconciliation ([Waghid, 2014](#_ENREF_37)). The Ubuntu philosophy or ideal must be made central to Africa’s education policy processes, systems, and agents’ actions, and must be evoked for an effective re-visioning of Africa’s education ([Takyi-Amoako & Assié-Lumumba, 2018](#_ENREF_34)). This is because, currently, philosophy and related ideals are lacking in the educational policies and systems of the continent. This absence has culminated in an incongruent link between who Africans are as a people and the educational systems that are meant to help unlock and develop their talents and potential for socio-economic development.

In the cultural and philosophical views of Africa, the individual forms an essential component of the community or society and can only exist corporately inextricably from the community ([Takyi-Amoako & Assié-Lumumba, 2018](#_ENREF_34)). State (Country) interventions in education and the classroom are only legitimate in an emergency ([Smeyers, 2018](#_ENREF_32)). Training is indispensable as the true human goal for the liberal order. Yet, on the other hand, the state should be denied the power “to promote training by building up regulation and financing of a public-school system”. More than ever, the essence of education has to be re-considered. The traditional education in Africa had this holistic, integral personality development notion of education. This was lost when *schooling* replaced education and when *educating for adaptation to life* was replaced by education for paid employment ([Takyi-Amoako & Assié-Lumumba, 2018](#_ENREF_34)).

**Education and Training in Disaster, Crisis and Internal Displacement**

EiE can be seen as quality learning opportunities for all ages in situations of crisis, including early childhood development, primary, secondary, non-formal, technical, vocational, higher, and adult education ([MoE, 2013](#_ENREF_19)). In this regard, United Nations International Children's Emergency Fund (UNICEF) in Ethiopia has been engaged in Education in Emergencies. On the other hand, Global Education Cluster – Ethiopia- has forwarded principles of Education in Emergency response and preparedness Strategies ([MoE, 2021c](#_ENREF_22)): *Preparedness, Responsiveness, Continuity and alignment, Harmonization,* and *Evidence.* These strategies are more detailed than the global tool that articulates the minimum level of educational quality and access in emergencies through to recovery ([MoE, 2013](#_ENREF_19)). The tool “INEE Minimum Standards for Education” incorporates Preparedness, Response and Recovery. From the Ethiopian point of view, the assumed strategy is ensuring the continuation of education in emergencies ([MoE, 2021a](#_ENREF_20)). Correspondingly, the two indicators would be: percentage of schools in emergency-prone areas with preparedness plans; and, percentage of schools providing uninterrupted primary education in emergency-affected locations.

The surveyed governmental and NGO’s policies, guidelines and concrete initiatives may remind, any concerned stakeholder in the education sector of Ethiopia, that a cross-cutting program on education in emergencies has to be well endorsed. For instance, NGOs functional in Ethiopia are assigning of experts in the area of EiE by the titles: “Education in Emergency Coordinator”, “Education in Emergency Senior Manager”, “Early Childhood Care and Education in Emergency Technical Advisor”, “Education in Emergency Specialist” and “Durable Solutions Expert”. Thus, an expert or coordinator or advisor or manager may need to acquire a skill of imagination which could be defined as the ability to deal resourcefully with unexpected or unusual problems, circumstances, etc. Seeking attitudinal change might be a key resolution. In spite of the substantial financial and technical support of the education systems in Africa, the continent can claim to negligible educational returns ([Takyi-Amoako & Assié-Lumumba, 2018](#_ENREF_34)). Then, the leadership and management of education, in the situation of emergency, need to be viewed broadly.

**Taking Mathematical Views**

Mathematical literacy includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena ([Bethell, 2016](#_ENREF_4)). The issue of “Education for All” can be translated mathematically as follows.

where refers to an individual person; corresponds to “education for and individual person”; and denotes “for all”. Then, the motto “education for all” as represented by , can be fulfilled only if every human being has the access to education.

**Topological viewpoint**

Flying in the sky at 24,000 plus feet distance from the ground gives a different world view. When I look down to the earth, I feel that the ground looks to be a flat surface. The territories or boundaries of each administrative region are of course *imaginary lines*. That could give a great insight to groups of people that fight for land and result in displacement and migration. Besides, such an observation would lead to playing in a space rather than a ground. So, the dimension would be broader. I am now in a position to state a definition.

a literal meaning the term *topology* may be *top-o-logy* and implies to study [the surface] from top.

Indeed, the thought may rather refer to *topography*. In this regard, Ault (2018) noted that *topological maps* can be studied from a topological point of view as well. According to Ault, a map is a *continuous function* from one space to another. Now, let me re-consider *topology* as the study of qualities of space that are preserved under invertible maps ([Ault, 2018](#_ENREF_3)). It is the natural evolution of the notions of proximity and continuity ([Ghrist, 2014](#_ENREF_13)). In a sense that a deformed (changed) object and its original shape are *equivalent*. In order to tackle unpredicted situations in the education sector, educators might be equipped with a mathematical perspective of *if-then*. In Mathematics, someone may say “let” or “assume” and continue his/her argument. That means, Mathematicians usually make assumptions they are pleased to study if they are consistent and serve some useful purpose.

*EiE* “can be considered as the set of activities that allow structured learning to continue in situations of emergency, crisis, or long-term instability”. I want to emphasis on the concept *set*. To deal with the concept, let me state a formal definition for topology ([Bradley, Bryson, & Terilla, 2020](#_ENREF_5)) and think forward.

A topological space consists of a ***set*** and a collection of subsets of that satisfy the following properties:

1. The empty set and are in .
2. Any union of elements in is also in .
3. Any finite intersection of elements in is also in .

Then, is called a *topology* on , and the elements of are called *open sets*.

If is to Ethiopia, and refers to social identities in the country, then, looking for intersections and unions would be helping citizens in living safely. It is observed that people are thinking of closed social identities. This could be reflected in boundaries and territories related concerns as they fight for land property. However, if I fly above the ground, I can see that the closed ones are *open sets*. *Topology* was built to distinguish qualitative features of spaces and functions ([Ghrist, 2014](#_ENREF_13)) including: characterization, continuation, integration, and obstruction. Thus, in advance planning of education in case of emergency, in the future is like considering that nothing is happening now but with a possibility of forthcoming events and changes. Here, the mathematical concept *zero* and *empty set* can be referred. It is possible to bring them into operation and study related properties.

**Geometrical Perspective**

When we think of the history of mathematics, names of Egypt and Greek would come into our mind. Geometry and Arithmetic were among the first branches of Mathematics. Geometry begins in Egypt ([Tabak, 2011](#_ENREF_33)) where Nile River overflowed its banks and washed across the fertile fields. It is evident that much of the tributaries of the river came from Ethiopia. According to Tabak, the motivation for the development of Egyptian geometry was, apparently, the desire for quick and accurate methods for surveying the farmers’ fields. In response to these simple demands the Egyptians soon developed a simple geometry of mensuration, the part of geometry that consists of the techniques and concepts involved in measurement.

The word Geometry used to refer to geo-metric and literary means measuring on (the surface of) earth. Yet, it can be treated as the study of shapes ([Tabak, 2011](#_ENREF_33)). It has great visual appeal, and it is also important because it is an example of a rigorous logical system where theorems are proved on the basis of postulates and previously proved theorems.

The issues of sustainability, climate change, human trafficking, and modern slavery are areas for the use of mathematics of uncertainty due to the lack of accurate data ([Mordeson & Mathew, 2021](#_ENREF_23)). It is reported that sub-Saharan Africa continues to lag behind most of the world when it comes to socioeconomic development with one in three Africans is at the risk of food insecurity. Here comes the concern of EiE. In Federal Republic Democratic of Ethiopia (FRDE), lots of displacements and migrations are observed. The extent is even tough; it is also being reported that massacre or slaughter are targeting a specific social identity or ethnic group. The concept of identity may be deployed to consider such a political act ([Darragh, 2018](#_ENREF_8)). The situation may be represented by the conception of parallelism in hyperbolic geometry (see Figure 1). In a sense, at least two social identities compete with one identity.

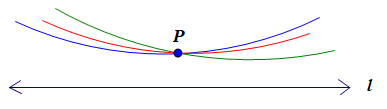


Figure 1: The Existence of Lines through a Point Parallel to another Line

Here, the (topological) properties of intersection and union are minimally considered. However, an alternative and equivalent conception of parallelism may be more relevant. In the globe, the imaginary lines of longitude meet at the North Pole and South Pole (see Figure 2). The interpretation is that every pair of great circles has a point in spherical geometry ([Dillon, 2018](#_ENREF_9); [Meserve, 1983](#_ENREF_18)) or elliptical geometry which may be visualized as the geometry of points on a sphere, with each pair of diametrically opposite points identified as a single point ([Meserve, 1983](#_ENREF_18)).



Figure 2: Using the Globe as a Model for Spherical Plane

In such a perspective, the geometers can directly articulate their own parochial axioms with respect to their justificatory status and inquiries into how the interior models of these otherwise self-standing schemes relate to one another ([Wilson, 2020](#_ENREF_39)). The ideology could impact someone to think of globally than locally. The above geometry is articulated by extending the radius of the sphere indefinitely. That leads to the consideration of north and south poles as *points at infinity* (see Figure 3). As the radius increases indefinitely, the arc (curve) becomes line segment angles. So, the implication to the Ethiopian context is this: peoples have the same root, and they tend to go to the same destination in the eternal life.

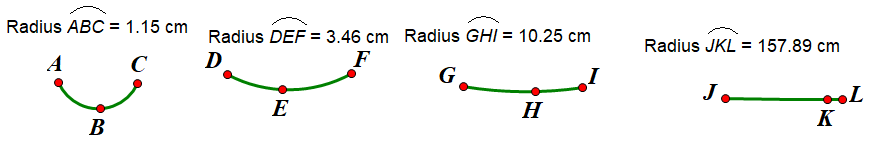


Figure 3: Parallel Lines Meet at Infinity

On the other hand, an imagination of *infinity* would enable us to bypass the problems that trigger conflicts and displacements in the country which might have happened due to scarcity of resources. At least, such thinking may bring relief in general. When it comes to schooling, the following remark could give some hints. how to co-exist with typical school mathematics learning contexts, still striving to change ourselves as mathematics educators by consciously using new epistemologies to re-make our realities, and supporting the efforts of those in these environments, while simultaneously working toward social change ([Appelbaum, 2018](#_ENREF_2)). Whereas classroom instruction is more secular by regulation, the education system is mostly situated in the context of instability. Particularly, EiE would require getting rid of psychological, socio-political and economical effects. That would in turn demand a perspective to look at. Again, applying the socio-cultural and socio-political perspectives in mathematics education might imply a realistic educational program.

* 1. **Discussion**

In this 21st century, students are expected to construct their own knowledge and solve real life problems by thinking critically as well as using their own creativity in collaboration with other peers. It is assumed that they come together having varied backgrounds, interests and experiences. On the other hand, modern education is aimed at transmitting to future generations the experience, traditions and culture, practical and scientific knowledge ([Narkabilova & Khujamberdiyeva, 2021](#_ENREF_26)). In order to maintain relevance and imagination as reference points for working with education and learning, be it in schools or enterprises, the latter is more foundation than the former ([Elkjaer, 2018](#_ENREF_10)). Therefore, developing student’s Geometric thinking would be helpful. What type of geometry? The discovery of non-Euclidean geometries has brought multiple truths. That could imply to the supposition of Mathematics is neither absolute nor rigid. The takeaway is that an education system has to give opportunities for students in developing perspectives and methods.

Ethiopia has been revising its educational policy and curricula. A new educational road map, a general education curriculum framework, the sixth educational sector development plan, new educational materials publication and educational policy were released. These are promising enablers of transformation. Yet, the process of reforming the education system demands continuous interventions.

I assume that an approved curriculum is not 100% complete. It could be further contextualized according to the focus area of an institution. Besides, it is subject to enrolled students and assigned academic staffs experience and engagement. Then, curriculum would have teaching, learning and assessment core processes which are interconnected to one another. Therefore, an optimum effort is expected from stakeholders concerning the issues. For example, in the classroom context, schools, colleges and universities may arrange internships, work placements, field experiences, game creation, meetings or events, not-for-profit consulting or volunteering for their students as they are highly regarded as a valuable learning experience in the real world ([Tan, Laswad, & Chua, 2022](#_ENREF_35)). To extend the concern a little bit further, we can regard “experiential learning” as guiding paradigm.

**Seeking a Creative Thinking**

Ethiopia has included “creativity” as a core competency in its general education and curricula. Unlocking creativity has been a concern for many authors and educators ([Alexander, 2022](#_ENREF_1); [Fournier, 2017](#_ENREF_12); [Krishnaswamy, 2019](#_ENREF_17); [Schroeder, 2017](#_ENREF_31); [Usher, 2015](#_ENREF_36)). It is thought provoking. Is creativity innate or learned? If it is blocked or locked, who locks it? And what is the ultimate goal of such locking? Aren’t children born “Tabula rasa” as John Locke has been credited for? Or, “do schools kill creativity” as Sir Ken Robinson used to say? Oh… Is creativity locked? Who locked it …? Where is the key? Who is going to un-lock …? When will it be un-locked, and, why?

**Out of School Programs**

Many higher education institutions focus too much on intra-curricular and co-curricular activities while neglecting extracurricular activities ([Munadi et al., 2021](#_ENREF_25)) which would have been providing a foundation for experiential learning and create a supportive environment within which students enhance entrepreneurial skills and knowledge about entrepreneurial activity. Those activities give experiences ([Nguyen, Nguyen, Phan, & Vu, 2021](#_ENREF_28)) and become a key theme of both national and international employability agendas ([Griffiths, Dickinson, & Day, 2021](#_ENREF_14)).

In these days, educational standards assume students acquire knowledge, continuously, expanding and enriching their horizons ([Narkabilova & Khujamberdiyeva, 2021](#_ENREF_26)). Activities such as school teams, clubs, student council, or school-wide campaigns are shown to have positive student-teacher relationships, friendships, social networks, sense of belonging, self-confidence for student development, and enjoyment of school ([Ng, 2021](#_ENREF_27)). This idea is enclosed in the third component of the second program of ESDP VI. Generally, the role of soft skills at school could emerged as important factors for students’ academic achievement ([Rahman & Hundal, 2021](#_ENREF_30)) and life satisfaction ([Feraco, Resnati, Fregonese, Spoto, & Meneghetti, 2022](#_ENREF_11)). Thus, taking part in extracurricular activities helps develop various skills and dispositions that make studying easier ([Kravchenko & Nygård, 2022](#_ENREF_16)). In other words, ECA provides evidence of its positive impact on academic performance ([Munadi et al., 2021](#_ENREF_25)) and wellbeing, and enhances employability skill ([Mukesh, Acharya, & Pillai, 2022](#_ENREF_24)). Most competencies that employers are looking for cannot be learned but can be developed by participating in extracurricular activities ([Hui, Kwok, & Ip, 2021](#_ENREF_15)). Contrary to this is the argument that participation in extracurricular activities (ECAs) adversely affects students' academic achievement ([Dang & Viet, 2021](#_ENREF_7); [Ozkan, 2020](#_ENREF_29)). The challenge might be this: planning for participation in extracurricular activities is difficult, given the lack of measurement standards together with their unstructured and non-systematic nature ([Hui et al., 2021](#_ENREF_15)). Above all, there is no agreed definition of what constitutes an ECA within the HE context ([Griffiths et al., 2021](#_ENREF_14)).

1. **CONCLUSION**

As far as the term “education’ is concerned, there are three common versions: formal education, non-formal education, and informal education. When schooling or learning is situated in contexts of challenges or crisis, formal education could be insufficient. For that matter, curriculum development would be complemented with implicit values to be obtained from the teacher and environment. Thus, Education requires the involvement of both classroom and extra-curricular activities in the education system ([Narkabilova & Khujamberdiyeva, 2021](#_ENREF_26)). In this regard, out-of-classroom programs provide a valuable experiential learning opportunity for students ([Tan et al., 2022](#_ENREF_35)) to establish interests, friendships and social networks in an informal setting ([Ng, 2021](#_ENREF_27)).

It may also be fair to pose a question: how to be a political social change Mathematics Education activist ([Appelbaum, 2018](#_ENREF_2))? Thus, **the term “topology” is re-conceptualized and implied for the EiE. It** is regarded as observing from the space. **Similarly, the concept “parallelism” is re-interpreted in light of elliptical geometry and implied for solution to the socio-political scenario of Ethiopia whereby** there exists parallelism of ethnic identities. Since the world of Geometry is diverse, a spherical geometers’ assumption of parallelism is revealed. That is, humans came to this world from one source and would have one destination in the eternal life. An understanding the space we are living in would enable us be global thinkers. All in all, a pan-Africanism ideology and an Ubuntu oriented proactive leadership of the education and training programs are advocated. From mathematical point of view, developing student’s Geometric thinking would be helpful. The education system has to give opportunities for students in developing such perspectives and methods.

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