Bridging the STEM Education Gap Among Secondary School Female Learners: Need for an Integrated Secondary School STEM Education Monitoring Tool

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Abstract
The under-representation of girls in science, technology, engineering and mathematics (STEM) education in developing countries has been, and continues to be, an issue of global debate. As a result, a study was undertaken to explore factors affecting STEM education including the learning and teaching environment of students and teachers. This paper presents research findings on secondary school STEM leaners especially girls and their teachers located in rural and urban, private and public schools in Malawi. Using leaner (532 leaners:263 males and 269 females and teacher (90 teachers: 60 males and 30 females) surveys in 15 districts, the results show that more leaners 28.3%, 24.5%, 22.3%,11.8% and 3.8%of leaners are in public schools located in urban areas, community day urban, private urban, community day rural and public rural respectively. Most of female leaners were enrolled in public urban (14.0%) whose parents (29.1%) have secondary school education. The most significant geographical variation on factors affecting enrollment came in from the problem of lack of facilities (p-value =0.019), demotivation from pressure (p-value =0.00), shortage of qualified teachers (p-value =0.02), and lack of teacher bridging programs (p-value=0.00. The findings suggest engaging an integrated digital secondary school monitoring tool. The tool has different features for different end-users including students' profiles, enrollment tracker, school calendar, class schedule, report card generation, assessment and grading, parents' and teacher's information among others. The tool will create an enabling environment for quality education by generating evidence on quality of teaching and learning and ensuring gender balance in enrollment. Furthermore, the tool will promote governance with insights generated from the available data.

Keywords: STEM Education, Monitoring Tool, Female Learners

1. Introduction

Globally, the concept of gender-inclusive education has taken a center stage in the development discourse and practice (Byrne, 2019). This has also been linked to the UN Declaration of Rights to Education (Loma, 2017). Within the policy programming, gender-inclusive education has also been linked to 'leaving no one behind' slogan and has mostly been advocated in developing countries (Vargas-Tamez, 2019). Gender-inclusive education is an approach to education that recognizes and addresses gender inequality and promotes gender equality for all students (Halldén & Helgesson, 2020). It recognizes the diversity in gender identity and expression and embassies on creating a safe, supportive and welcoming environment for all students regardless of gender identity (UN, 2022; Write et al., 2016).

Several projects including UN Women STEM education and leadership program, UNESCO Engineering for Sustainable Development project, UNICEF Innovations for Education initiative, UNDP STEM for Development project, have been supporting both inclusive education as well as right to education (Kurth et.a.,2018; Kostelnik & Stein, 2019). However, the number of children failing to access education has been increasing (UNESCO, 2017).

While the right to [quality] education is a universal human right, many developing countries are facing difficulties in meeting this obligation. This has led to several consequences, particularly among low-income communities (Srivastava et al., 2015). In addition, poor policy programming and support for STEM and sanitation education have led to increased number of learners dropping out of school. For example, over one million learners in Malawi have not been able to complete primary school education, whilst only 60-70% of primary school graduates attend secondary schools (UNICEF, 2021). For those that have made it to secondary school, very few learners especially females opt for Science, Technology, Engineering and Mathematics (STEM).

Previous studies have revealed that despite policy interventions of increasing percentage of female learners in natural sciences and technology degrees from 25% to 60% (GoM, 2012), female students in STEM are still under-represented in the field (Mbano and Nolan, 2017). The situation is even worse when it comes to sanitation education across all levels of education resulting in few female experts advancing both STEM and Sanitation education (Shaw et.al. 2019). Reasons for this have been discussed with possible reasons varying from constraints at household level such as financial availability, lack of curriculum specialists, lack of policies and practical limitations such as lack of teaching and learning infrastructure (UNICEF, 2020).

This policy gap is further linked to lack of inclusive education monitoring tools that allow key factors such as parents, teachers, government officials to understand the trend and progress of learners in STEM and sanitation education. Recognition of the need for inclusive education monitoring tool that is both useful and usable is developing rapidly alongside a growing literature on dealing with inclusive education models (UNESCO, 2015). Understanding the wider learning environment for learners in developing countries especially females is critical since some of the factors are linked to social as well as wider group dynamics (World Bank, 2022). Longer economic outcomes of education led by STEM education to support SDG 4 will be affected due to non-use of tools and systems for monitoring education performance among female learners. This is particularly relevant in developing countries where the number of female leaners who are shinning away from STEM and sanitation education (AAUW, 2015). Locally adapted education monitoring tools can

support decision making among education actors that can allow learners to complete and excel in their STEM and sanitation education. A further consideration is that for inclusive education and leaving no one behind concepts to be supported by decision makers, there is need for new tools of monitoring education and programming that should be embraced by all actors (Elsa et.al. 2016).

Appropriate and timely development of inclusive education monitoring tool is inevitable for developing countries in general and specifically for Malawi. Malawi's education sector is faced with several challenges, including: low funding and insufficient resources, shortage of trained teachers, inadequate infrastructure, lack of basic school facilities, which affects enrolment and attendance, resulting in high dropout and low completion rates (GOM, 2017). According to Wamba and Mgomezulu (2014), factors such as poverty, lack of conducive environment, limited qualified teaching staff, teaching, and learning materials, infrastructure and overall policy support have been recognized to be critical in achieving inclusive education.

Using a case study from Malawi, through a survey, we iteratively engaged female learners and secondary school teachers from public and private secondary schools in both urban and rural areas in order to (i) understand the extent to which access to STEM and sanitation education is still hindered despite policy interventions (ii) to analyze teacher programming and monitoring in support of STEM and sanitation education among female leaners and (iii) conceptualize a STEM and sanitation education monitoring tool for inclusive education system. Our argument is that policy interventions should be supported with proper monitoring tools that do not only rely on data and information, but also other actors that indirectly affect education.

2. Materials and Methods

2.1 Study Area and Context

Malawi has one of lowest education enrolments in STEM and sanitation education in Africa, with the lowest number of students graduating with STEM degrees. The majority of learners are still having challenges accessing education in general due to lack of proper infrastructure among others. Teacher-pupil ratio in primary school is 1:59 whilst secondary schools is 1:72 (World Bank 2018). This situation is further worsened by high poverty rates. According to World Bank data, around 80% of the country's population live in poverty in 2015, with the majority of people residing in rural areas. The poverty rate is estimated to be around 60% and 90% in urban and rural areas respectively (World Bank 2022).

The Ministry of Education is responsible for all education levels in Malawi (early childhood development, primary, secondary, and higher education). The ministry and development partners have applied several development and policy interventions to promote girl education in general and particularly to promote STEM education among female learners (MoE, 2019).

This study took place in 15 districts in Malawi including Karonga, Nkhatabay, Mzimba, Rumphi Nkhotakota (northern region), Salima, Lilongwe, Dedza Ntchisi, Ntcheu (central region), Blantyre, Zomba, Phalombe, and Balaka in the southern region (See Figure 1). Within these districts, the survey covered urban and rural secondary schools represented by public conventional, community day secondary and private secondary schools. Community

Day secondary schools only operate during the day and do not provide boarding facilities and services whilst public conventional secondary schools accommodate students as boarders.

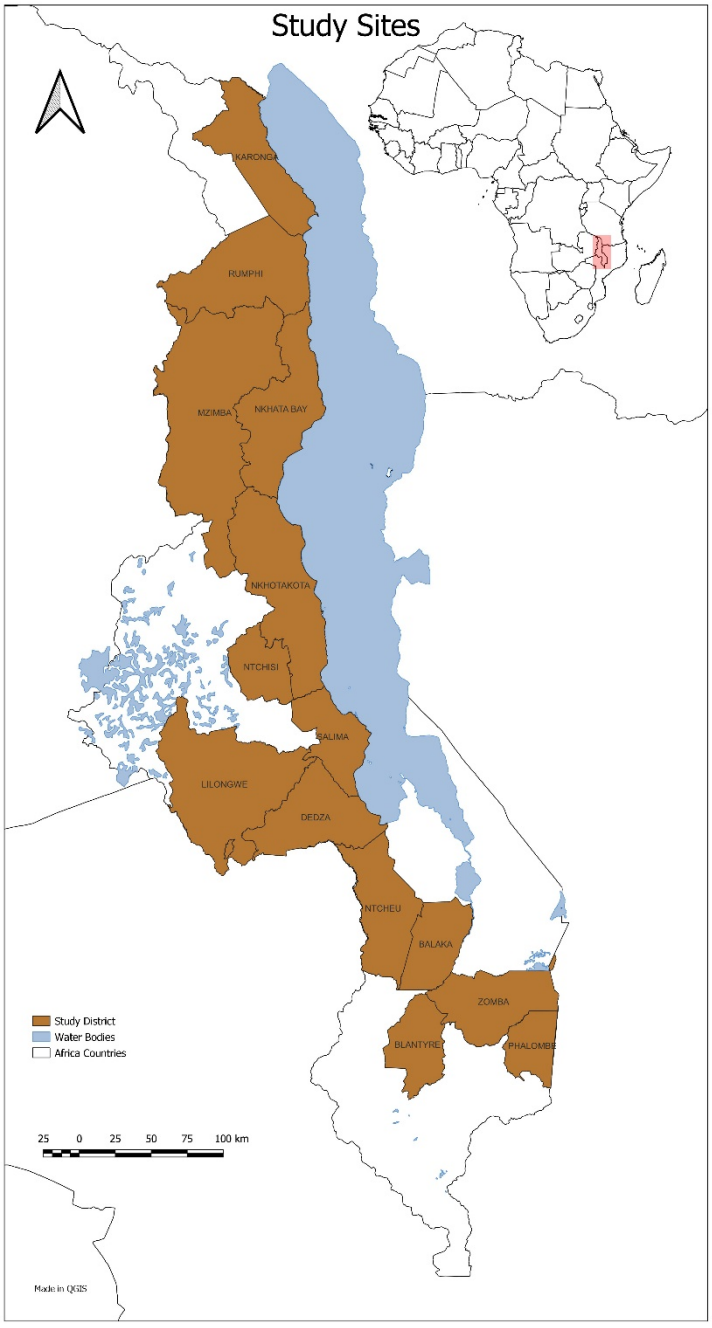


Figure 1: Study sites

2.2 Data Collection

A digital structured questionnaire on mWater Application was used to collect primary data. mWater is a cloud-based platform that provides tools for monitoring and managing data. It offers different features including: mobile data collection, interactive maps, real-time data visualization and reporting, data sharing and collaboration and integration with other systems and data sources. Using the digital tool surveys with open and closed questions were conducted at each secondary school. The surveys covered details of school information,

demographic information, enrolment into STEM subjects, barriers to STEM education, and sanitation in different modules. In total, 45 secondary schools were sampled covering community rural (8.9%) and urban (18.8%), public rural (18.9%) and urban (30.0%), private rural (4.4%) and urban (14.5%) and faith based secondary schools (4.4%).

Students and teachers from the sampled secondary schools were conveniently sampled and were informed and asked for consent to participate in the survey. Twelve (12) students (6 males and 6 females) and three (3) teachers including the head teacher were interviewed in each secondary school. In total 532 students (263 males and 269 females), 90 teachers (60 males and 30 females) and 42 head teachers (33 males and 9 females) were interviewed from 9 January 2022 to 27 May 2022. The questionnaire was initially written in English and then translated into Chichewa, the main local language to enhance understanding during interviews. The research assistants were graduates from Mzuzu University and Malawi University of Science and Technology. The variables that were studied and included in the questionnaire for leaners, teachers and head teachers are provided as supplementary materials in Annex 1.

2.3 Data Analysis

Data were analyzed using Stata 17. Stata is a software suite that provides a range of tools for data management and statistical analysis. It offers a variety of features that were used in this study including data management, data visualization, descriptive statistics, and inferential statistics among other features. Spatial analysis was done in Stata using GIS boundary information and spatial data from study dataset to produce choropleth maps. The maps were produced to show patterns, distribution and interactions of the data across the districts to gain insights based on geographic context.

The study employed descriptive statistics supported by Student t-test and Pearson chi-square, to analyse factors affecting female enrolment in STEM education. Furthermore, geospatial analysis was conducted to explore regional variation to inform policy on interventions necessary to support secondary schools.

3. Results and Discussion

3.1 Who are the Learners and Teachers in Malawian Secondary Schools

Table 1 has results on who are the learners. The majority (52.8%) of learners (66.7% males and 33.3% females) are aged between 18-21 years followed by those aged 14-17 (45.1%) whereby 60.8% were females and 29.5% were males).

Table 1 Social demographics of sampled students

		Community Day		**Faith Based**	**Private**		**Public**		**Total**
		Rural %	**Urban %**		**Rural %**	**Urban %**	**Rural %**	**Urban %**	
Gender	Male	47.7	50.0	38.9	47.8	49.4	52.1	50.3	**49.4**
	Female	52.3	50.0	61.9	52.2	*50.6*	47.9	49.7	**50.6**

Age	14-17	35.4	42.4	61.1	39.1	39.**5**	35.4	54.8	**45.1**
	18-21	56.9	56.8	38.9	60.9	56.8	64.6	44.1	**52.8**
	22-25	7.7	0.9	0.0	0.0	3.7	0.0	1.1	**2.1**
Main source of income for head of households	Business	27.7	34.8	50.0	39.1	29.6	27.1	23.5	**29.3**
	Farming	46.2	17.8	0.0	17.4	13.6	31.3	27.4	**24.4**
	Formal employment	15.4	35.6	38.9	34.8	46.9	33.3	41.3	**36.7**
	Informal employment	3.1	8.5	5.6	8.7	4.9	8.3	4.8	**5.8**
	Others	7.7	3.4	5.6	0.0	4.9	0.0	3.4	**3.8**
Highest qualification of head of household									
	Primary	40.0	22.9	11.1	13.0	14.8	31.3	18.4	**22.2**
	Junior Secondary	15.4	11.0	11.1	4.4	7.4	12.5	6.2	**9.2**
	Senior Secondary	24.6	33.9	55.6	34.8	34.6	14.6	34.1	**32.0**
	Tertiary (University.	13.9	21.2	22.2	39.1	29.6	29.2	29.6	**25.9**
	No idea	3.1	9.3	0.0	8.7	9.9	4.2	8.9	**7.7**

These results show that despite reported low gender disparities in Malawian primary schools, as the learners progress to senior classes the ratio turns with more male leaners than female leaners (NSO, 2017). According to literature, underrepresentation of girls in secondary schools in Malawi is caused by socio-cultural factors, financial constraints, access to schools, early marriage and pregnancy, and discrimination and biases (UNFPA, 2022; Lovell, 2021; Malongo, 2016). In terms of enrolment versus type and location of secondary school, the study found that the majority (28.3%) of learners are in public schools located in urban areas. These are followed by community day urban (24.5%) private urban (22.3%) and community day rural (11.8%) whilst public rural had fewer students (3.8%). Most of the female learners were enrolled in public urban (14.0%), community day urban (12.1%), and private urban (11.3%). Public rural schools tend to lack appropriate infrastructure as well as teachers. The living standards for teachers also affects teacher availability with lack of energy as part of the challenge.

Most learners come from male headed households (72.5%) compared to those from female headed households (27.5%). It was further observed that most of learners' parents (29.1%) have secondary school education followed by those with tertiary education (28%) and

primary education (22.5%). The main source of income for their guardians/parents is formal employment (38.2%) followed by farming (23.4%). The results show that there is gender gap in female learners in rural areas versus those in urban areas (**Pearson chi2(1) = 0.0021)**. This gender disparity is alarming, especially as STEM careers are often referred to as the jobs of the future, driving innovation, social wellbeing, inclusive growth and sustainable development (UNESCO, 2023).

Since STEM education is crucial for sustainable development, there is need for policy intervention and implementation of different initiatives to address these gender disparities and attract female educators pursue STEM career (UNICEF, 2020). Furthermore, due to the variation in leaners social-economic background, the initiatives have to be made in such a way that all parents get engaged to render support to their children education (UNESCO, 2020; OECD, 2016). Digitization can enhance information flow and participation of parents through an inclusive digital portal accessible through feature phones, smart phones, radio programs and other means. The tools may further promote diverse contribution, information sharing on different opportunities and offer equal education and opportunities to all (Anastasiou & Papagianni, 2020).

3.2 Typical Landscape and Contexts of Secondary Schools in Malawi

Results (see Table 2) show that most (71.2%) teachers in secondary schools visited have a bachelors degree as their highest qualification followed by those with diplomas (23.4%). Only four teachers (10%) of the 90 consulted had a masters degree with few teachers having Malawi School Certificate of Education (equivalent to O-levels). There were more (79%) male teachers especially in the centre (31%) and the north (29%) compared to the south (19%). In terms of age, the results show that more teachers (62%) have over 50 years of age followed by those in the age range of 35-39 years. Most of there were teaching Mathematics (51.1%), Chemistry (45%), Biology (36.7%) and Physics (35.5%). Only 6.6% and 1.1% were teaching computer studies and Additional Mathematics respectively.

Table 2 Social demographics of sampled teachers

		Community Day		**Faith Based**	**Private**		**Public**		**Total**
		Rural %	**Urban %**		**Rural %**	**Urban %**	**Rural %**	**Urban %**	
Gender	Female	12.5	35.3	25.0	50.0	15.4	41.2	40.7	33.3
	Male	87.5	64.7	75.0	50.0	84.6	58.8	59.3	66.7
Highest qualification	Bachelors Degree	37.5	58.8	50.0	75.0	76.9	76.5	85.2	71.1
	Diploma	50.0	35.3	50.0	0.0	23.1	17.7	11.1	23.3
	MSCE	12.5	5.9	0.0	0.0	0.0	0.0	0.0	2.2
	Masters	0.0	0.0	0.0	0.0	0.0	0.0	3.7	1.1
	Teaching	0.0	0.0	0.0	25.0	0.0	5.9	0.0	2.2

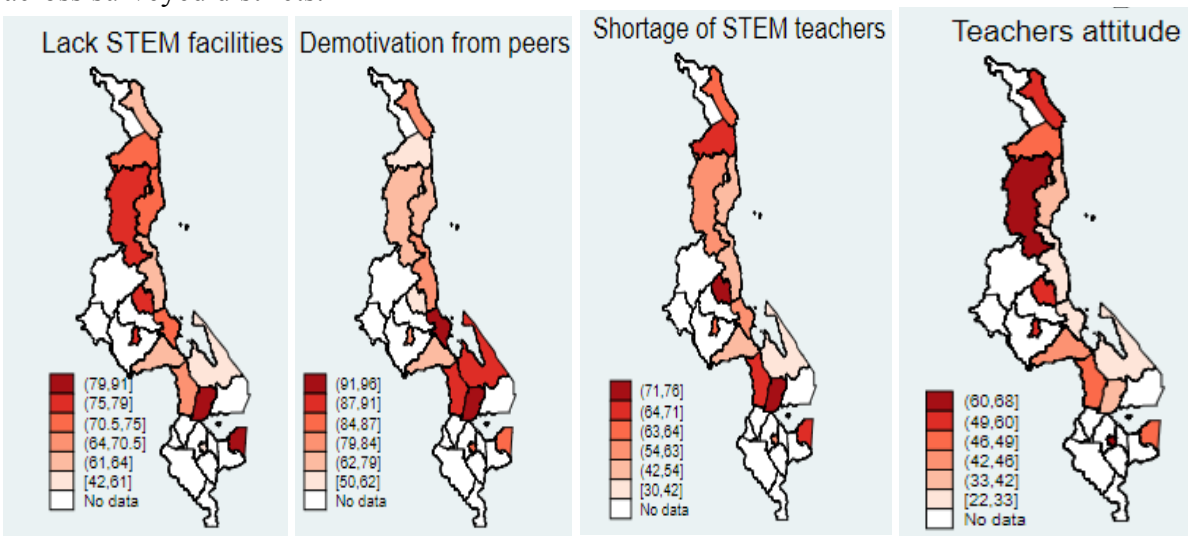
	Certificate								
Aware of NESP	Yes	50.0	35.3	75.0	0.0	15.4	35.9	44.4	36.6
	No	50.0	64.7	25.0	100.0	84.6	64.7	55.6	63.3
Training	Yes	75.0	70.6	75.0	50.0	53.9	64.7	66.7	65.5
In STEM& Sanitation	No	25.0	29.4	25.0	50.0	46.2	35.3	33.3	34.4

Most of the teachers (51.1%) have attached STEM education and they teach mathematics (51.1%) followed by chemistry (45.4%) and physics 35.5%. Few of them are teaching computer studies (6.6%) and additional mathematics (1.1%).

In terms of age, the study found that these children are being taught by teachers who are 50 years old and above (62%) followed by those aged between 35-39 years (17%). Policy need to support professional development, monitor and evaluate the gap in teachers' expertise and inform teachers in a convenient way to be aware of education policies. Utilising emerging technologies would optimise teaching practices and enhance overall students' outcome (UNESCO, 2015; Kim et al., 2022).

3.3 Factors Hindering Access to STEM Education by Learners

Results show that 69.2% of the sampled students agreed that lack of or insufficient learning facilities such as laboratories, affect enrollment in STEM education. The results further show that 77.4 % of the students perceive that pressure from peers highly affects enrollment of females into STEM education whilst 52.6% and 47.6% indicated that shortage of qualified teachers and teachers' attitude towards females, affect enrollment of female students into STEM subjects respectively. Figure 2(a-d) shows a geographical variation of the constraints across surveyed districts.



2a ***2b*** ***2c*** ***2d***

Figure 2 Factors hindering access to STEM education

The most significant geographical variation came in from the problem of lack of facilities (p-value =0.019), demotivation from pressure (p-value =0.00), and shortage of qualified teachers

(p-value =0.02). Based on the surveyed districts the problem of lack of insufficient facilities registered high in Balaka, Salima and Ntcheu (2a); whilst demotivation from peers registered high in Mangochi, Balaka, Ntcheu, Zomba, and Salima, (2b); shortage of qualified teachers registered high in Ntchisi, Balaka and Rumphi (2c) and the problem of attitude of teachers towards female students registered high in Mzimba (2d).

UNICEF reported similar results on various factors including lack of resources social-cultural norms, financial constraints, limited access to schools, early pregnancy and early marriages contributing to high number of males than female leaners in Malawian secondary schools(UNICEF, 2021). To address these gender disparities there is need of policy support in promoting stakeholder engagement and utilizing available resources. Among other stakeholders' parents are key in supporting inclusive education (Dollinger et al., 2022). Currently, parents are mostly involved through the Teacher-Parent Association whose mandate is limited to quality education especially for a girl child (GOM, 2017). There is need for a proper tool that includes them to get actively engaged in education monitoring. Digital tools can be utilized as a means to enhance parental involvement and communication to allow parents to play an active role in their children education to support teachers (Anastasiou et al, 2020). Apart from parents, other organizations can easily collaborate through different projects to support STEM education and the system can provide information of schools getting support and underprivileged schools that need more support Cleland & Lumsdon, 2021).

3.4 Factors Hindering STEM Teaching Programming

Based on perceptions of surveyed teachers, 98% of the teachers agreed that there is lack of bridging programs while 74% agreed that there is need for STEM training to improve STEM education in secondary schools. Results show a significant variation in teachers' perception on factors hindering teaching programming (See Table 3). These findings are similar to other studies that emphasised the need for training and professional development for teachers (Vidakis et al., 2019; Ejiwale, 2013). According to Mervis (2011), an inspired teacher inspires students.

Table 3 Factors hindering teaching programming

Variable	**Chi2**	**CDSS**		**Faith**	**Private**		**Public**		**Total %**
		Rural %	**Urban** %	**Based** %	**Rural** %	**Urban** %	**Rural** %	**Urban** %	
Lack of bridging program	***0.00***	12.0	10.0	2.0	5.0	17.0	17.0	36.0	98.0
Lack of STEM training	***0.07***	10.0	7.0	5.0	2.0	5.0	17.0	29.0	74.0
Policy issues	***0.08***	4.0	7.0	2.0	0.0	0.0	8.0	12.0	33.0

The success of facilitating student's activities depends on how well STEM educators have been prepared for the challenges they will face in class. Therefore, there is need for more policy support as results show 50% of teachers agree that there are some policy issues that are

hindering STEM education. These results indicate a need for collaboration and networking opportunities for teachers. Digital tools can serve as a platform for dissemination of information on training opportunities, exchange programs, policy workshops to support all teachers in improving the provision of quality education. Furthermore, online resources can be easily shared to enhance knowledge and skills in STEM education (Pernaa et al, 2022).

4. Monitoring Framework for Inclusive STEM Education

Set against the results and within a broad context of growing economic, social and educational problems and a complex and sometimes, ineffectual institutional setting for an inclusive STEM education, understanding how different actors including guardians, teachers and education officials can help play a positive role in STEM education requires developing an integrated digital secondary school monitoring portal. Thus, it is of upmost relevant to allow key actors including guardians, teachers, educationists and policy makers to use modern monitoring application (MA) tools in STEM trends for inclusive education, especially in developing countries.

4.1 Current Gaps and Challenges on Existing STEM Portals

Despite efforts and interventions made in the development of existing STEM portals, the initiatives face several challenges and some gaps remain unexplored (OECD, 2016; UNESCO,2022). Majority of the systems available offer online resources and support to students and teachers (OECD, 2020). Current available STEM platforms include Khan academy, Ghana STEM school portal, TEDEd, NASA STEM Engagement, among others. In Malawi students lack access to online resources and in many cases the content available differ from the local curriculum (UNESCO, 2022; GOM, 2019). Many public secondary schools in Malawi do not have websites and students portal. This leaves them at a disadvantage from communicating to the international community for possible collaboration and joint projects.

4.2 Components of the Proposed System to Address the Gaps

The proposed tool contains different features for different end-users including students, teachers, guardians, policy makers and development partners. The first component is the students profile which contains students demographic and academic information, to understand the heterogenous interest of students and their personal goals for easy provisions of necessary support. The second component is the student grades that show performance of the students in different subjects and enables understanding students' strength and weaknesses of students across subjects. The third component is fees and financials, which shows fees payments and balance and provides information for available financial support for different needy students.

The other component is the enrollment information which provides summaries of students' enrollment in different subjects across classes, schools, region and at national level. The syllabus component provides clarity for relevant information of what is supposed to be covered in different subjects to help in planning. Institutions component provides for contacts for linkage to different institutions that provide services in the education sector. The feedback component provides for engagement and reviews for various programs to get feedback for possible improvements. Settings enable users to set preferred privacy priorities and users can

sign in as students, guardians, teachers, institution representative and administrators to access policy dashboard.

4.3 Functions of the Tool

The system is proposed to perform the following functions: signing up and log in as different users with two-factor authentication; creation of profiles and linking databases between students, teachers, guardians and school administration. Furthermore, the system may serve as a communication hub between students, teachers, parents, and the wider school community and provide a great wealth of information about the schools' mission, vision, policies, and projects. In addition to that information on enrollment, school calendar, and students' performance may be shared and lastly generation of report cards. Different features will be made available based on roles of different users of the system.

The tool will create an enabling environment for quality education by generating evidence on quality of teaching and learning and ensuring gender balance in enrollment. Furthermore, the intervention will promote governance with insights generated from the available data.

4.4 Information to be Generated

Among other useful data, the system will generate real-time enrollment data, student performance data, students and teachers' profiles to help in monitoring and evaluation of different programs and provide for national feedback data on what needs to change or improve (OECD, 2016). The development may assist in adjusting projects and programs and allow easy collaborations among institutions.

4.5 Application of the Portal

The tool will enable tracking female enrolment in different schools for possible policy interventions to archive gender gaps in STEM education. Using available APIs and machine learning tools different trends will be analyses across years or terms to generate insights on the variation and determinants of different factors bringing in the variations in STEM education (Baker & Uckelman, 2018). Furthermore, the tool will facilitate communication between teachers, students, and parents to enhance accountability and transparency in education delivery and to encourage collaboration among different stakeholders (Schleicher, 2018; OECD, 2019). The system will generate notifications for various profiles that have the opportunity for certain scholarships and grants.

The tool will also generate real-time data for informed policy decision making with regards to national target (World Bank, 2021). This information may provide a bases from which schools can learn from each other and overall learning what works and what doesn't from ongoing initiatives. Lastly the tool may help in facilitating national planning and resource allocation to fit in current gaps.

5. Conclusion

Our argument is that the STEM tool will help in monitoring students' enrollment and performance in STEM education from Form 1 to Form 4 and will generate information for policy makers and all stakeholders in education sector. The platform will create an enabling environment to facilitate quality education, promoting human capacity with regards to gender

in STEM education and enhance collaboration among organization in promoting STEM education at national and global level.

The tool will be accessible through different convenient and secured platforms i.e., website, mobile application, SMS and USSD or Call service for relevant Stakeholders including parents to be informed of the current trends on students' education for appropriate interventions and support. Apart from informing policy, the tool will enable parents or guardians to register with respective secondary schools to be able to keep track and monitor performance for better parental advice or initiatives. With a proper system in place, students with special talents may be identified, teachers and schools may also learn from each other in forums based on the generated data.

At the national level, students' enrollment and performance data will be readily available for all relent stakeholders. Through a secured portal, head teachers will be able to upload consolidated results and access data insights through a dashboard. Different funding opportunities or events will also be shared through the platform for the schools and students. This will enable interested organizations to collaborate in joint programs for bigger impact.
Conceptual frameworks have been used by researchers, development agencies and governments for decades to understand everything from interaction of poverty and environment and the links between ecosystems and social systems (Parkes *et al*., 2003); and the importance of community participation in decision making (Ellis, 2000).

Other frameworks have utilised indigenous knowledge to understand scientific research problems (Jarvelin and Wilson, 2003), while the majority have been used by scientists to generate new ideas and concepts on issues affecting the human kind (Downs, 2007). These are constructed in order to present information logically (Midgley, 2007) and they capture the essential concepts of systems (e.g. function, system and requirement) and guide in understanding the outputs and outcomes of the systems.

A conceptual framework for advancing inclusive STEM education monitoring, however, seems to be missing. As such, government programmes and resource allocation are based on learning from other sectors. While findings have revealed several institutional and structure gaps for STEM education, actors are lacking a proper framework that clearly help to shape roles and functions of different actors to support female leaners.

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References

Anastasiou, S. & Papagianni, Aggeliki. (2020). Parents', Teachers' and Principals' Views on Parental Involvement in Secondary Education Schools in Greece. Education Sciences. 9. 69. 10.3390/educsci10030069.

Ayalon, H. L. (2013). Educational standardization and gender differences in mathematics achievement: A comparative study. Sage, 432–445.

Baker, M. a. (2013). Boy-girl differences in parental time investments: evidence from three countries. National Bureau of Economic Research (NBER), http://www.nber.org/papers/w18893

Besold, T. R. & Uckelman, S. L. (2018). Normative and descriptive rationality: From nature to artifice and back. Journal of Experimental & Theoretical Artificial Intelligence, 30(20), 331-344. doi: 10.1080/0952813X.2018.1430860

Cleland, Jonathan & Lumsdon, David. (2021). How can school – parental participation support the generation of social capital for parents? Educational and Child Psychology. 38. 19-39. 10.53841/bpsecp.2021.38.2.19.

Dollinger, Mollie & Harvey, Andrew & Naylor, Ryan & Mahat, Marian & D'Angelo, Belinda. (2022). A student-centred approach: Understanding higher education pathways through co-design.

Eagly, A. H. (2012). Social role theory," in Handbook of Theories of Social Psychology, Thousand Oaks, CA: Sage.

Else-Quest, N. M. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. Psychol. Bull., 136, 103–127. doi: 10.1037/a0018053

Elson & Seth. (2019). Gender equality and inclusive growth: economic policies to achieve sustainable development. NY: UN Women.

GOM (2017). Girls' Primary and Secondary Education in Malawi: Sector Review Final Report: Ministry of Education Science and Technology, Lilongwe

Hill Nancy (2022). Parental involvement in education: Toward a more inclusive understanding of parents' role construction, 10.1080/00461520.2022.2129652,:Educational Psychologist

Houjeir, R. &. -K.-D. (2019). UAE Females in STEM higher education. CASET, 1-6. 10.1109/I.2019.8714543.

Jennifer Dusdal, Justin J W Powell, Benefits, Motivations, and Challenges of International Collaborative Research: A Sociology of Science Case Study, Science and Public Policy, Volume 48, Issue 2, April 2021, Pages 235–245, https://doi.org/10.1093/scipol/scab010

Kim, Insook & Ko, Bomna & Oh, Daekyun. (2022). Professional Development Policies and Practices for Developing Content Knowledge of Physical Education Teachers. International Journal of Kinesiology in Higher Education. 1-13. 10.1080/24711616.2022.2130843.

Kurth, Jennifer & Miller, Amanda & Gross Toews, Samantha & Thompson, James. (2018). Inclusive Education: Perspectives on Implementation and Practice from International Experts. Intellectual and developmental disabilities. 56. 471-485. 10.1352/1934-9556-56.6.471.

Miller, D. E. (2015). Women's representation in science predicts national gender-science stereotypes: evidence from 66 nations. Journal of Education Psychology., 107:631-644.

Mohtar, L. &. (2019). A MODEL OF INTEREST IN STEM CAREERS AMONG SECONDARY SCHOOL STUDENTS. Journal of Baltic Science Education, 404-416.

Moorhouse, E. (2017). Sex segregation by field of study and the influence of labor markets: Evidence from 39 countries. International Journal of Comparative Sociology, 58: 3–32.

National Planning Commission (2020). Malawi 2063. Lilongwe: National Planning Commission

Nosek, B. A. (2002). Math = male, me = female, therefore math≠ me. J. Pers. Soc., 83:44. doi: 10.1037/0022-3514.83.1.44

OECD (2019). Improving School Quality in Norway: The New Competence Development Model, Implementing Education Policies, OECD Publishing, Paris, https://doi.org/10.1787/179d4ded-en

OECD (2016). Innovating Education and Educating for Innovation: The Power of Digital Technologies and Skills, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264265097-en

OECD (2020). The Pursuit of Gender Equality: An Uphill Battle Paris: OECD Publishing.

Pernaa, Johannes & Kanematsu, Hideyuki & Godoy, Michal & Zúñiga, Elisa & Pérez, Javiera & Cassot, Del & Carrasco, Eduardo & Tomljenovic, Marijana. (2022). OPEN ACCESS EDITED BY Development of digital and science, technology, engineering, and mathematics skills in chemistry teacher training. Frontiers in Education. 7. 10.3389/feduc.2022.932609.

Schleicher, A. (2018). World Class: How to Build a 21st-Century School System, Strong Performers and Successful Reformers in Education, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264300002-en

Shaw, S. M., Bothwell, M., Furman, K., Gaines, L., John, D., Lopez, C., Osei-Kofi, N., Özkan-Haller, H. T., Plaza, D., Ruder, B., & Warner, R. L. (2019). Advancing women in STEM: institutional transformation. *Lancet (London, England)*, *393*(10171), e17–e18. https://doi.org/10.1016/S0140-6736(19)30206-5

UNESCO (2023). Gender imbalances remain in digital skills and STEM careers. Accessed from http://uis.unesco.org/en/blog/gender-imbalances-remain-digital-skills-stm-careers on May 4th 2023

UNICEF (2021). UNICEF Annual Report 2021., Lilongwe, Malawi: United Nations Children's Fund (UNICEF).

Vargas-Tamez, C. (2019). Leaving no one behind: Bringing equity and inclusion back into education. In L. Tett & M. Hamilton (Eds.), Resisting Neoliberalism in Education: Local, National and Transnational Perspectives (pp. 239-252). Bristol University Press. doi:10.46