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Towards Education Delivery Through E-learning in an Environment of Scarcity of Teachers: A Case of A-level Science Education in Tanzania

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***Abstract*- E-learning platforms are transforming the way education delivery is done in a significant way. Key to this transformation is the broadband-enabled internet, now being promoted under broadband-for-all global policies, which is facilitating how students learn beyond the walls of the classrooms. As students learn at their own pace with e-learning, teachers serve and act as facilitators guiding and helping out where students find difficulties in certain concepts. This is transforming the way education is delivered and allows teachers to put more attention on students with difficulties (slow learners) while the more capable students (fast learners) can move on to new concepts at their own pace. There are many e-learning platforms in use today. This paper focuses on those platforms dealing with delivering secondary level education; specifically science education at the advanced-level (A-level) secondary schools. A review of existing e-learning platforms is presented with the aim of identifying requirements for and justification of developing an improved e-learning platform that supports interactivity, collaboration and motivational engagement of learners throughout the process of education delivery. The output of this analysis review shows that most of these platforms currently in use do not support a holistic way to engage students in an interactive and collaborative manner, which is known to motivate learning and at the same time develops within learners collaboration, creativity, communication and critical thinking (4Cs) mindset necessary for the 21st century learning. It is desirable to have a platform that supports interactive education delivery and student collaboration in learning by engaging students, teachers (facilitators) and parents (guardians).**

Keywords: E-learning, Platform, Education delivery, Science studies, Secondary schools.

I. INTRODUCTION

Globally, there is shortage of teachers for science subjects. In the case of sub-Saharan countries, there is a need to increase the number of teachers by 68% from 2.4 to 4 million in less than a decade [1]. The shortage of teachers is a result of many factors including poor working conditions and minimum wages, which have contributed to about 77.2% of teachers' terminations and turnover seeking for green pastures for the case of Tanzania secondary schools [2].

Another cause of shortage of teachers is increased student enrollment mostly due to government policy of free basic education, which has been attributed by programs such as the Primary Education Development Plan (PEDP) and Secondary Education Development Plan (SEDP). These programs have contributed to an increase in students-teacher ratio especially in the science subjects [3]. This shortage of science teachers in secondary schools is degrading education delivery, which in a way undermines scientific contribution in a country like Tanzania.

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Furthermore, education delivery at advanced secondary level lacks skills delivery mechanism that prepares the student for todays' digital competitive world. However, e-learning blending with traditional learning at advanced secondary school level is known to have the potential to improve student's digital competency skills and support teachers in education delivery [4]. It is also known that, in traditional educational delivery, learning is more teacher centered with single path progression as student's act more as receivers of information. This tends to isolate the students rather than activating them towards a collaborative way of exchanging information [4].

Today the traditional education delivery is being replaced by broadband-enabled e-learning in which education delivery no longer focuses on producing information. Instead, education delivery focuses on guiding, facilitating the learner (student) to validate information, synthesize information, leverage information, communicate information, collaborate information and problem solve with information. Encouragingly, there are many e-learning platforms in use today most of which are too generic with varying content; hence fail to meet the learning requirements for a specific scholar group, i.e. secondary schools. Other platforms that target or support secondary schools education delivery fall short on the ability to effectively engage and motivate student learning.

As a case study, this paper provides a comprehensive analysis of the education delivery effectiveness of popular e-learning platforms in use to support/supplement provision of Tanzania secondary education. The analysis is intended to establish important features/criteria that need to be followed when developing a holistic e-learning platform. The scope of the presented analysis is limited to advanced-level government secondary schools, excluding vocational studies.

The paper is organized as follows: Part II shows analysis of student's performance in science and non-science studies. Part III discusses the proposed criteria for e-learning platforms; while Part IV shows the selection of study platforms. Part V presents the findings from the analysis on the selected platforms and Part VI concludes the paper.

II. WHY A DIFFERENTIAL PERFORMANCE IN SECONDARY SCHOOLS BETWEEN SCIENCE AND NON-SCIENCE LEARNERS?

Figure 1 shows the performance, in terms of graded learning outcomes, of advanced-level secondary school students for the period of 10 years. The data shows just an average performance. Tables 1, 2 and 3 show average aggregate division points for 30 government advanced-level secondary schools; while Tables 4, 5 and 6 show corresponding results for 30 non-government advanced-level secondary schools, all having both science and non-science subjects streams, and placed in a category of schools with more than 30 students per stream in the National Examination Council of Tanzania (NECTA) grading system. The 30 schools in each category of government and non-government represent 10 best performers, 10 average performers and the 10 least performers in the Advanced Certificate of Secondary Education (ACSEE) results for the year 2014 and 2016. In the NECTA grading system, grades points are assigned as follows: A (1), B (2), C (3), D (4), E (5), S (6), and F (7). A student at A-level sits for a combination of three subjects and the division scored is assigned based on total points for three subjects as follows: Division I (3 - 9); Division II (10 -12); Division III (13 - 17); Division IV (18 -19) and Division 0 (20 -21). Lower average aggregate points means better performance in terms of learning outcomes – corresponding to higher division; and higher aggregate points means not as good performance in terms of learning outcomes – corresponding to lower division. Table 7 shows overall average aggregate points for the year 2014 in which science students passed

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at higher aggregate points of 10.75 (Division II) whereas non-science students passed at lower aggregate points of 8.87 (Division I). Again, for the year 2016 science students passed at higher aggregate points of 13.22 (Division III) whereas non-science students passed at lower aggregate points of 11.78 (Division II). The overall poor/lower performance of science students compared to the performance of non-science students is a result of many factors among which scarcity of teachers and shortage of educational materials in secondary schools especially in the science streams is more critical. Convincingly, these results justify the research work being done.

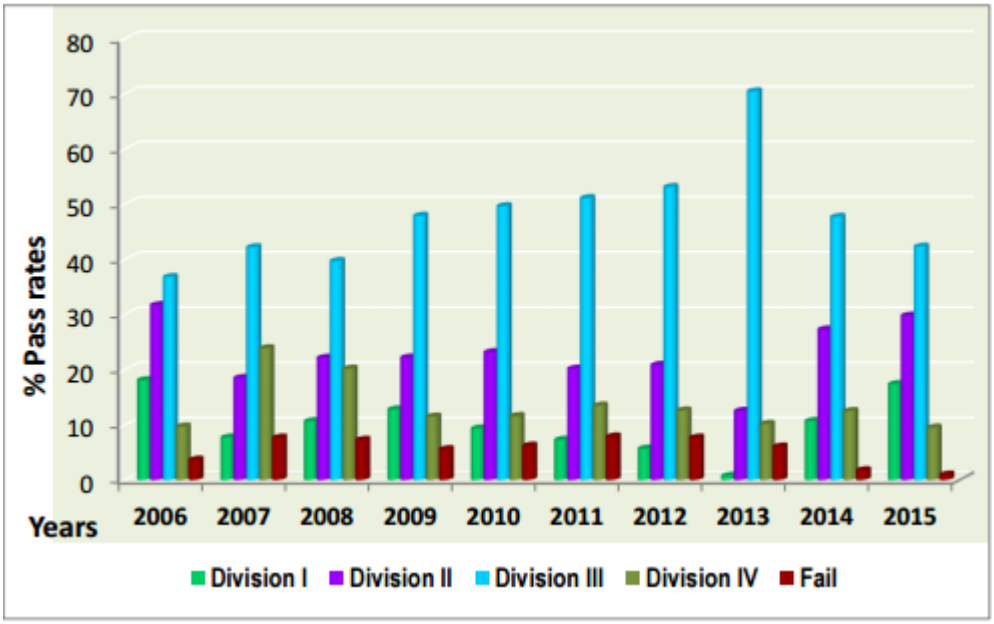

Figure 1: Secondary Education Pass Rates Summary of Form 6 Examination (ACSEE) in Government and Non-Government Schools, 2006-2015, BEST 2016 – Case of Tanzania [2].

TABLE 1: SECONDARY EDUCATION AGGREGATE DIVISION POINTS FOR TOP PERFORMING SCHOOLS 2014 -2016 NECTA – CASE OF TANZANIA [5].

2016			**2014**		
Schools	**Science**	**Non-science**	**Schools**	**Science**	**Non-science**
Tabora boys	8.31	10.46	Uwata	9.20	7.72
Kibaha	9.69	8.55	Kibaha	7.89	5.96
Mzumbe	9.24	10.15	Mzumbe	8.08	7.96
Ilboru	9.72	9.09	Msalato	8.58	7.00
Tabora girls	9.95	9.50	Kisimiri	8.36	6.00
Msalato	10.21	9.95	Ilboru	8.46	8.11
Runzewe	11.57	10.06	Tabora girls	8.81	8.20
Uwata	10.22	10.28	Tabora boys	8.44	8.75
Msolwa	11.23	10.54	Mpwapwa	9.84	7.98
Tlawi	12.55	10.21	Weruweru	11.56	7.86
Average	**10.27**	**9.88**	**Average**	**8.92**	**7.55**

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TABLE 2: SECONDARY EDUCATION AGGREGATE DIVISION POINTS FOR AVERAGE PERFORMING SCHOOLS 2014 -2016 NECTA – CASE OF TANZANIA GOVERNMENT SCHOOLS [5].

2016			2014		
Schools	**Science**	**Non-science**	**Schools**	**Science**	**Non-science**
Loleza	13.35	11.43	Nganza	11.12	8.47
Nganza	13.79	10.83	Longido	10.83	8.53
Pamba	13.92	11.85	Mbeya	10.88	9.77
Kondoa girls	13.53	10.88	Kondoa girls	11.01	7.50
Longido	13.61	11.01	Ifunda girls	10.33	9.06
Mbeya	14.16	12.21	Lugalo	10.45	9.16
Kazima	13.94	11.99	Iringa girls	10.32	9.42
Bugene	14.88	11.37	Malagarasi	10.93	8.56
Tunduru	14.45	10.89	Korogwe girls	10.78	8.07
Ndanda	13.47	11.31	Machame girls	10.58	8.64
Average	**13.91**	**11.38**	**Average**	**10.72**	**8.72**

TABLE 3: SECONDARY EDUCATION AGGREGATE DIVISION POINTS FOR LOWER PERFORMING SCHOOLS 2014 -2016 NECTA – CASE OF TANZANIA GOVERNMENT SCHOOLS [5].

2016			2014		
Schools	**Science**	**Non-science**	**Schools**	**Science**	**Non-science**
Lufilyo	15.37	13.08	Tambaza	11.68	10.36
Same	14.02	11.53	Same	11.18	9.02
Minaki	14.11	13.21	Minaki	10.67	10.35
Pugu	14.09	13.50	Ndanda	11.18	10.47
Jangwani	15.91	12.80	Mahiwa	11.33	9.85
Songea boys	15.12	14.56	Kalangalala	10.78	9.65
Shinyanga	15.44	13.63	Shinyanga	11.10	9.90
Bagamoyo	15.52	13.42	Bagamoyo	11.31	10.17
Lumumba	15.25	15.20	Lumumba	10.72	11.08
Azania	16.06	14.10	Azania	10.72	9.62
Average	**15.09**	**13.50**	**Average**	**11.07**	**10.05**

TABLE 4: SECONDARY EDUCATION AGGREGATE DIVISION POINTS FOR TOP PERFORMING SCHOOLS 2014 -2016 NECTA – CASE OF TANZANIA NON-GOVERNMENT SCHOOLS [5].

2016			2014		
Schools	**Science**	**Non-science**	**Schools**	**Science**	**Non-science**
Feza boys	8.09	9.89	Feza boy's	7.34	7.23
Alliance girls	9.07	9.41	St.mary's mazinde	9.30	7.53
Feza girls	9.05	9.37	Marian girls	8.04	7.50
Marian boys	8.78	10.24	Feza girls	8.30	7.00
Marian girls	9.42	10.31	Kirinjiko islamic	10.33	8.14
St mary's mazinde	9.70	9.75	St.mary goreti	9.24	8.87
Pandahill	10.23	9.92	St.joseph cathedral	9.62	8.17
Kifungilo	9.76	10.60	Alfagems	10.80	8.46
Donbosco-didia	12.02	9.20	Al-muntazir	9.03	9.42
St.james	11.63	9.91	Barbro-johansson	10.71	8.10
Average	**9.78**	**9.86**	**Average**	**9.27**	**8.04**

TABLE 5: SECONDARY EDUCATION AGGREGATE DIVISION POINTS FOR AVERAGE PERFORMING SCHOOLS 2014 -2016 NECTA – CASE OF TANZANIA NON-GOVERNMENT SCHOOLS [5].

2016			2014		
Schools	**Science**	**Non-science**	**Schools**	**Science**	**Non-science**
St.maurus chemchemi	15.70	12.25	St.antony	10.34	9.34
Sanu seminary	13.45	12.18	Taqwa	11.69	9.60
Winning spirit	14.50	11.95	Airwing	10.88	9.30
Loreto girls	12.98	12.05	Thaqaafa	11.28	9.60
Simba wa yuda	12.92	10.67	St.christina girls	10.86	9.70
Thaqaafa	14.30	11.50	Alpha	10.66	9.09
Masama girls	13.73	11.65	Bendel memorial	10.44	8.80
Rosmini	13.50	11.68	Consolata seminary	10.38	8.57
Masjid qubah	12.90	10.90	Tusiime	10.89	8.98
Bigwa	15.06	11.00	Jitegemee	11.63	9.26
Average	**13.90**	**11.58**	**Average**	**10.90**	**9.22**

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TABLE 6: SECONDARY EDUCATION AGGREGATE DIVISION POINTS FOR LOWER PERFORMING SCHOOLS 2014 -2016 NECTA – CASE OF TANZANIA NON-GOVERNMENT SCHOOLS [5].

2016			**2014**		
Schools	**Science**	**Non-science**	**Schools**	**Science**	**Non-science**
Ben bella	17.50	14.29	Ben bella	11.47	11.02
Green bird boy	16.95	14.21	Majengo	11.05	9.67
Tanzania adverntist	17.48	12.63	Lutheran junior	10.86	10.78
Al-ihsan girls	16.09	14.08	Edmund-rice-sinon	11.87	9.76
St.mathews	16.36	14.51	Lord baden powel	11.33	9.53
Etatha seminary	16.5	12.77	Mazizini	11.79	11.15
Imboru	15.51	12.37	Al-falaah muslim	11.73	9.43
Mlima mbeya	16.44	14.56	Makita	11.73	9.43
Anne marie	16.55	13.46	Iwalanje	11.58	8.42
Fidel castro	14.80	13.56	Taqwa	11.48	9.70
Average	**16.42**	**13.64**		**11.49**	**9.89**

TABLE 7: COMBINED 30 SCHOOLS AVERAGE FROM HIGHER, MEDIUM AND LOWER PERFORMANCE SCHOOLS.

	2014		2016	
	Science	Non-science	Science	Non-science
Government	10.95	8.70	13.09	11.87
Non-government	10.55	9.05	13.36	11.69
Overall average	**10.75**	**8.87**	**13.22**	**11.78**

As reported in [6], and confirmed by the foregoing performance analysis, most students prefer non-science subjects due to lack of science teachers and study materials, where schools have few teachers and sometimes these teachers have to borrow books from students to teach. The impact of such inadequacy and scarcity often translates into student's performance where non-science students show higher performance in terms of graded learning outcomes compared to science students as shown in Table 7.

III. PROPOSED CRITERIA FOR E-LEARNING PLATFORMS

In order to get a comprehensive analysis of the existing platforms, it was deemed necessary to categorize the features of e-learning platforms into two main criteria, namely: motivation to learn and support systems for learning. In this categorization, learning motivation has 3 sub criteria and support systems for learning has 5 sub criteria.

A. Motivation to Learn Criteria

For students to learn in a personalized learning environment such as e-learning platforms, the platforms need to motivate learners through interactivity, collaboration and engagement of learners to learners and learners to tutors. This main criterion is intended to determine how a platform motivates learners to love coming back to learn more [7]. Items in each feature are shown in Table 8 and the criteria are described as follows:

a) *Interactivity:* The platform should be interactive with contents that motivate learning, i.e. structured notes, animated/graphics and video tutorials [8].
b) *Collaboration:* The platform should have embodied collaboration tools that create a connected environment for the learners and tutors. Such tools include chat rooms, discussion forums, and E-mail [9].
c) *Engagements:* The platform should engage a learner into participation through assessment activities such as projects, assignments, interactive exercises and feedback.

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B. Support Systems Criteria

In accordance with the P21's Framework for 21st Century learning, education provision does not stop only on the content delivery (key subjects) alone as a single output a student is supposed to possess. Students do need knowledge, skills, expertise and literacy to blend well in the new digital competitive environment of today. In Figure 2, The P21's framework for 21st century defines the outputs a student should possess (shown as rainbow) and the learning structures as inputs to support the student outputs (represented at bottom) [10].

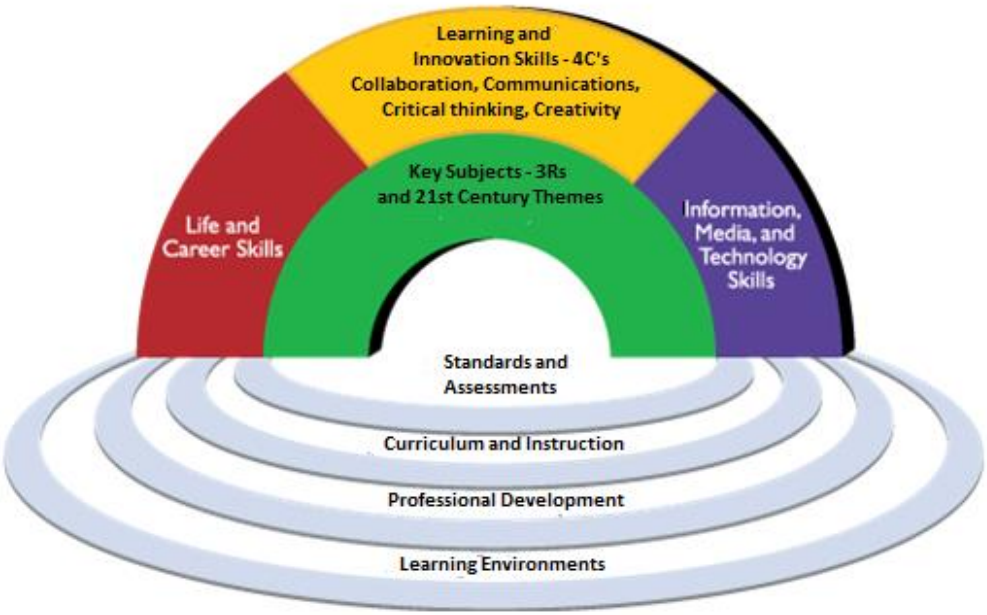

Figure 2: Partnership 21st Century learning Framework [9].

For an e-learning platform to comply with P21 Framework for 21st Century learning it should ensure that it is built on supporting systems that ensure appropriate, supportive and empowering standards and assessments, curriculum and instruction, professional development and learning environment, all are in place. And all these should be well defined to meet the desired outputs to the learner. These outputs are centered around the 4C's: Critical thinking, Communication, Collaboration and Creativity. The list of support systems is shown in Table 9 and described as follows:

a) *Standards:* The key question here is: does the e-learning platform emphasize on deep understanding of knowledge rather than shallow learning; engages students in problem solving, following national standards for a particular level and allows multiple measures of mastery?

b) *Assessments:* The learning platform should have a standard assessment testing, provision of useful feedback on student performance and also tracks on student portfolio of work, which elaborates student's mastery of concepts. The platform should be able to assess overall education system effectiveness [8, 11].

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c) *Curriculum and instructions:* Does the platform follow a defined curriculum for the intended audience, enabling innovative learning methods that inspire creativity and critical thinking?

d) *Professional development*: The platform should support cultivation of teachers' ability to identify students' particular learning styles, intelligences, strengths and weaknesses. In addition, the platform should support continuous evaluation of students' 21st century skills development and encourage knowledge sharing among communities of professionals (practitioners) through online webinars, which inspire professional careers.

e) *Learning environments*: Create learning practices, human support and physical environments that support the teaching and learning of 21st century skill outcomes and enable students to learn in relevant, real world 21st century contexts (e.g., through project-based or other applied work).

TABLE 8: MOTIVATION TO LEARN CRITERIA AND THEIR FEATURES.

Criteria
1.**Interactivity**
1.1 The platform should have structured contents and easy to use by students with clear visibility in color and font.
1.2 The platform should have animation contents for more elaborations
1.3 The platform should have graphics/pictures contents for visual understanding
1.4 The platform should have live or on-demand videos tutorials of elaborations.
2.**Collaboration**
2.1 Platform support for instant chat that supports text, voice note, images or videos.
2.2 Platform support for discussion forums.
2.3 Real time information of other students participating in solving challenges or learning similar content.
2.4 Inter-schools challenges.
3.Engagements
3.1 Platform support for interactive exercises and self-assessment
3.2 Prompt feedback support
3.3 Platform support for projects and assignments related to the content learnt
3.4 Platform support for guardian/parent engagement with their students activities through reports of student status at all time.

TABLE 9: SUPPORT SYSTEMS CRITERIA AND THEIR FEATURES.

Criteria
4. **Standards**
4.1 Platform supports for deep knowledge understanding
4.2 Engages students in problem solving
4.3 Allows multiple measures of mastery
5. **Assessments**
5.1 Standard assessment testing
5.2 Feedback on student performance
5.3 Track student progress and work portfolio
5.4 Overall education system effectiveness assessment.
6. **Curriculum and Instruction**
6.1 Define curriculum for learners
6.2 Enable innovative learning methods that inspire creativity and critical thinking
7. **Professional development**
7.1 Ability to identify students' particular learning styles, intelligences, strengths and weaknesses
7.2 Encourage knowledge sharing among communities of practitioners through webinars that inspires professional careers
7.3 Support continuous evaluation of students' 21st century skills development
8. **Learning environment (s)**
8.1 Support learning in real world 21st Century context (e.g., through project-based or other applied work).

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IV. METHODOLOGY

A. *Criterion for Selection of Study Platform*

After scanning through existing e-learning platforms that are currently used to support delivery of secondary education in Tanzania, the four e-learning platforms; hereby named as LMP1, LMP2, LMP3 and LMP4; were found suitable for analysis as per the research objectives of the reported study. The reasons for selecting thee platforms are briefly described in the following paragraphs:

a. *The LMP1*: The ***Shuledirect platform*** (www.shuledirect.co.tz) currently focuses on providing learning contents for O-level secondary schools. The platform has tried to identify the curriculum and syllabus for secondary schools in Tanzania from form I to IV and added materials in the form of text and graphics for student to read and learn. Currently the platforms have instructional materials for History, Civics, Geography, Physics, Chemistry, Biology, English, Mathematics, Kiswahili, Bookkeeping, Commerce and Life skills. Figure 3 shows the screen shot of the platform. Unfortunately, LMP1 is yet to include contents for advanced level education.

Figure 3: Screenshot of LMP1.

b. *The LMP2*: The ***mElimu platform*** (http://www.melimu.com) is an online e-learning environment where learners and tutors exchange information in the sense that tutors/teachers add learning contents on the platform and form classes for learners to benefit on the contents. Teachers get paid by the students/learners in exchange for the information. Figure 4 shows a screenshot of the platform. Since anyone qualified/authorized can upload content to the platform, it can be used for both O-level and A-level secondary education.

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Figure 4: Screenshot of LMP2.

c. *The LMP3*: The ***Studi web platform*** (www.studi.co.tz) provides learning contents for secondary schools currently for form I and II that are rich in animations and video material easy for a student to understand. Currently, it has science subjects: Mathematics, Physics, Biology and Chemistry. Figure 5 shows the Screenshot of the platform. Unfortunately, LMP3 as well is yet to include contents for advanced level education.

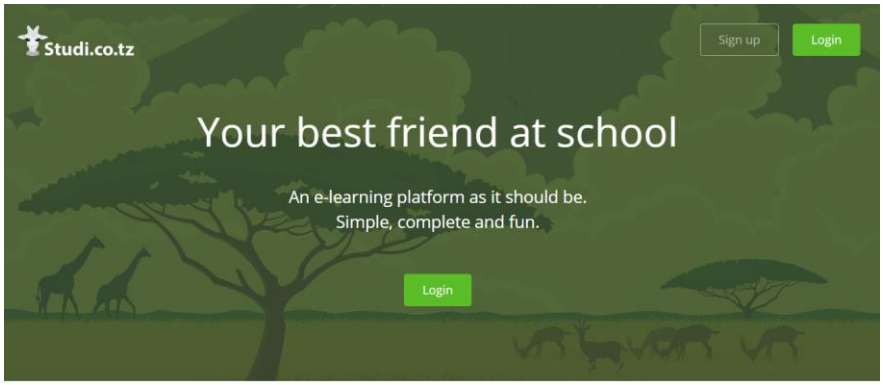

Figure 5: The Screenshot of LMP3.

d. *The LMP4*: The ***Thl 2.0 Revised edition platform*** (http://thlpc.com/) focuses on Tanzania secondary education for both O-level and A-level (from form I to form VI). The students can access learning notes and past papers. It is mostly accessible through mobile phones (smartphones) and has a software version for windows PC. The platform requires a student to pay subscription fees to access its contents. Currently the platform has notes for Biology, Physics, Chemistry, History, Commerce, Civics, Kiswahili, Bookkeeping, Geography, Basic Mathematics, Computer, English and Agriculture for O-level and Biology, History, Accountancy, Physics, Basic Applied Mathematics, Economics, General Studies, Advance Mathematics, English, Computer, Chemistry, Geography, Commerce, Kiswahili and Agriculture for A-level. Figure 6 shows a screenshot of the platform.

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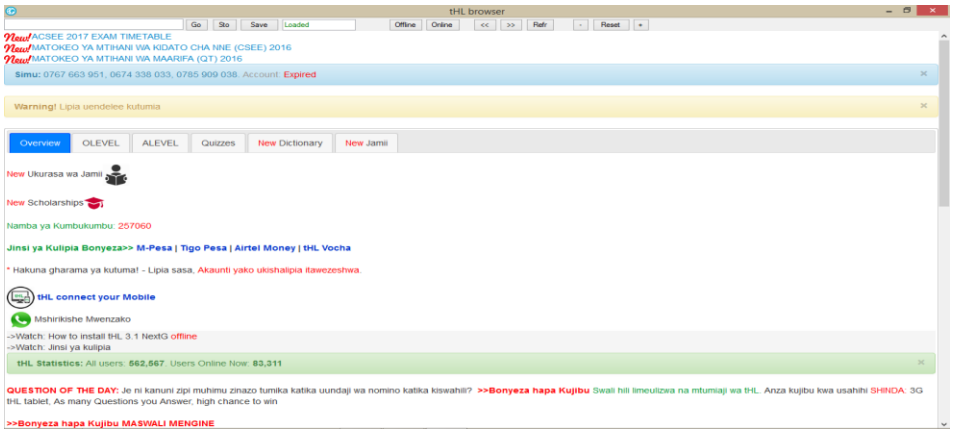

Figure 6: LMP4 screenshot.

B. *The Evaluation Process*

From the criteria given in Tables 8 and 9, the selected four e-learning platforms were analyzed and compared against each other to check whether they fit into any of the proposed criteria for an interactive motivational e-learning platform with 21st Century education delivery skills mindset. For each criterion, the associated features were checked against platforms to know how many are unsupported or not present/violated by the platforms.

V. FINDINGS AND DISCUSSION

From a total of 12 criteria in Table 8 and a total of 13 criteria in Table 9, a sum of 17, 7, 16 and 20 violations for e-learning platforms LMP1, LMP2, LMP3 and LMP4, respectively were observed. For the case of LMP1, 8 violations were related to learning motivation and 9 to support systems criteria. For the case of LMP2, 3 violations were related to motivation and 4 to support systems criteria. LMP3 had 6 violations related to motivation and 10 to support systems criteria. Finally, LMP4 had 6 violations related to motivation and 14 to support systems criteria as shown in Table 10.

TABLE 10: VIOLATIONS MATRIX FOR THE LEARNING MANAGEMENT PLATFORMS

Category	**Motivational criteria**			**Support systems criteria**					**Total Violations**
Criterion	1	2	3	4	5	6	7	8	
LMP1	3	3	2	2	2	1	3	1	17
LMP2	1	1	1	1	1	1	0	1	7
LMP3	0	4	2	3	2	1	3	1	16
LPM4	2	3	3	3	4	1	3	1	20

From the results of the initial analysis, it is seen that most existing selected platform exceeded over 50% of the total violations hence renders them incompetent in education delivery. Observable from Table 10, only the LMP2 has below 50% violations. It is a challenge to have a violation free platform but an acceptable optimum

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level of below 20% creates an ideal learning environment for student especially advanced level secondary students who are less exposed to the digital environment. It is important that when designing a learning platform to consider motivational and support systems features as they are key to creating a friendly learning environment where students communicate and collaborate effectively and at the same time are part of the learning process.

VI. CONCLUSION

The paper has reported on an ongoing research on the identification of criteria to guide the design of a holistic learning platform for delivery of secondary education in an environment of scarcity of teachers and learning materials. The reported initial work involved the analysis for compliance of existing learning platforms to deliver into learners the 4C's of the 21st Century learning; Collaboration, Creativity, Communication and Critical Thinking.

These initial results reveal that education delivery has many challenges. Among them is the influx of students amidst few teachers especially in science subjects. Apart from few teachers, study resources have been a challenge for both students and teachers as they fall short on materials such as books for learning. As observed, there are many e-learning platforms that try to supplement education delivery but many lack features that engage the students towards today's 21st Century competitive world. Therefore, an enhanced featured e-learning platform with 21st Century learning mindset that engages the students in a more collaborative and interactive manner is required for the case of Tanzania secondary schools especially advanced level Secondary School studies where the scarcity of teachers and resources is more critical.

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