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CONCEPT MAPS AS SEMANTIC TOOLS FOR DEVELOPING SERVICES ONTOLOGY: THE DIGITAL LEARNING ECOSYSTEM OF SELECTED BASIC SCHOOLS IN GHANA

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Abstract. In this paper, we explored Cmaps tools as semantic tool for modeling services ontology. The designed services ontology served as probable determinant of schools' Digital Learning Ecosystem (DLEO). DLEO of seventeen (17) specially selected schools for this study, were mapped on the services ontology. The study showed that many services intended for schools are missing on the services ontology, thus causing school exhibit less enhanced DLEO. Nonetheless, some key digital practices were found in schools; and these were organised around 1) ICT classes and 2) use of Laptops/Smart devices in limited cases to facilitate learning. We propose to stakeholders in schools to use DLS ontology (Fig 3) to as guide to assess their schools DLEO; and carve out interventions to address the digital constraints.

1 Introduction

In this paper attempt is made to use of CmapTools (Cañas et al., 2004) to advance the digital services ontology to define the Digital Learning Ecosystem (DLEO) of schools. The term DLEO is a metaphor denoting the makeup of digital learning services (DLS) in the form of tools, resources, users, and prevailing socio-cultural and economic environments mutually functioning towards the fulfillment of an established educational goals(Laanpere, Pata, Normak, & Põldoja, 2014). We hold the view that various digital services inform the trend of technology integration and state schools' DLEO - in the form of complex relations in the system. That using the principles of concept mapping we will be able to obtain a visual representation of semantic relations of services as it occurs in the schools' DLEO. The use of Concept maps is traced to Novak, who developed the idea in the 1960s (Cañas et al., 2003; Novak & Cañas, 2007); he used it to obtain visual representation of a structured information in the field of learning. However, concept maps could originally be traced to Ausubel's theory of meaningful learning. The underlying principle of Ausubel's theory was that one's acquisition of new knowledge is contingent on what is already internalised by this individual (Novak, 2011). Novak applied the principles surrounding the theory to develop systematic knowledge building schema that supported and consolidated learning and knowledge acquisition (Novak & Cañas, 2007; Novak & Gowin, 1984). Today concept mapping has become a useful approach for developing knowledge; it is an effective means of supporting, collaborating and sharing knowledge in various fields of study. CmapTools, is the application for building concept maps. In the works of (Cañas et al., 2003) the effectiveness of the application in the context of education and training was documented. Among many other valuable uses, the tool supports concept-mapping integration, supports collaboration and sharing of concept maps. It offers visual representation of systematic representation concepts and patterns of linkages among concepts.

According to(Cañas et al., 2003), concept maps as tools facilitates knowledge structuring and representation. In addition, (Martin, 1994) defined concept maps as "two–dimensional representations of cognitive structures showing the hierarchies and the interconnections of concepts involved in a disciple or sub discipline." It is worth mentioning that concepts in the context of our discourse is explained as the perception held about regularity in event or record as so represented on the concept map by a label (Cañas et al., 2003). Deductions from the discourse of (Cañas et al., 2003; D. Jonassen, Carr, & Yueh, 1998; D. Jonassen & Marra, 1994; Tergan, 2005) point to the fact that complex inter-relations among cognitive structures can be modeled in the form of concepts maps. With this backdrop, we infer that one's ideas, knowledge and flow of thoughts could be visualised in the form of concept maps with the aid of CmapTools.

Though, literature holds it that there is no particular way to develop concept maps, a typical approach to building concept maps is advanced by (Cañas et al., 2003; Novak & Gowin, 1984). They suggested the following sequence of operation for building concept maps;

1. Set focus question
2. List important concepts
3. Order concepts in top-down structure and hierarchically
4. Link concepts with required proposition/descriptions
5. Cross link concepts for further elaboration
6. Review concept map for improvement

From the scholarly point of view, concept maps has the potential to promote meaningful learning, offer parameters for evaluation and setting standards for improvement – through systematically developed linkages between concepts, events and resultant outcomes or interpretations of events outcomes (Cañas et al., 2003; Novak & Gowin, 1984; Novak, 2011). To this end, this paper advances ontology of Digital Learning Services (DLS) defining an enhanced Digital Learning Ecosystem (DLEO) of basic schools in Ghana. An ontology is defined by (Noy & McGuinness, 2001) as *"a formal explicit description of concepts in a domain of discourses, and with the properties of each concept describing various features and attributes of the concepts and restrictions on slots*". On his part, (Gruber, 1993) is of the view that knowledge can be represented formally in the form conceptualisation; and that the explicit specification of the conceptualisation of the body of knowledge would constitute an ontology. We deduce from this discourse and reviews (Amiel, Claudio, & Wives, 2016; Boyce & Pahl, 2007; Neumann, Finger, & Neumann, 2016) to make inferences that ontology is the representation of a view of a kind of knowledge system, inter-related events, or worlds, which represents a particular purpose within a particular domain. Thus, using CmapTools in our case we could develop a semantic relational of all DLS into a services ontology - to establish the status of schools' DLEO. Based on this premise, this paper reports the use of concept tools as semantic tools for designing services ontology for measuring schools' DLEO. The study was guided by two main objectives namely;

1. Build semantic relations of DLS items as probable ontology determinants of an enhanced DLEO
2. Apply concept maps as a semantic tool to establish schools' DLEO status.

2 Research Method and Approaches

2.1 Research Design and participants

A mixed design - qualitative and quantitative approach were used for the study. A structured rubric, which contained the indicators of the DLS were developed. It was meant to serve as the mapping grid for the qualitative data; which was used in measuring the state of the DLS in schools. We treated grid's data as quantitative measures of services in schools' DLEO.

2.2 Conceptual architecture

We advocated for a kind of enhanced DLEO based on the Digital Learning Services (DLs) ontology (Fig 1) that were organised in three layers/zones, namely; external, internal and transaction services. The external services are services provided by government and private institutions; adopted internally within schools' environment, and domesticated in the schools for use as transaction service; in the form of Infrastructure service, Learning Facilitation service and Change Management services (Jeladze & Pata, 2016; Quaicoe, Pata, & Jeladze, 2016).

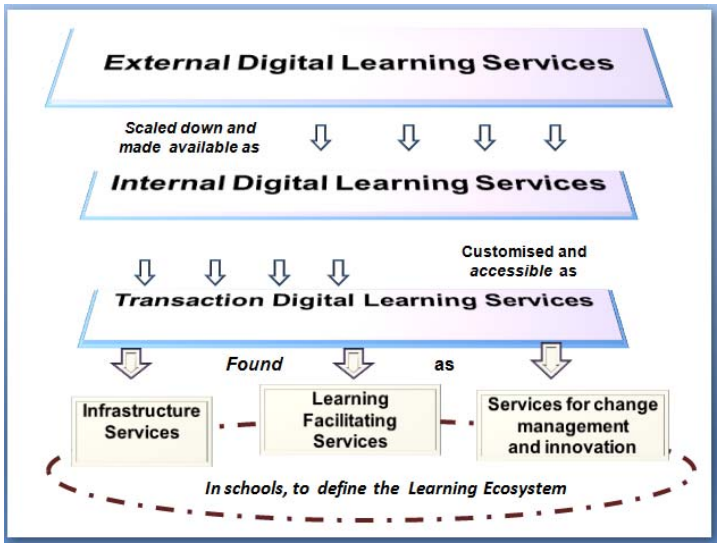

Figure 1. Initial conceptual architectural services ontology for schools.

2.3 Data collection and inputs

We devolved digital services rubrics, as grid on which qualitative data was mapped onto. The rubrics contained (205) services items grouped into three levels - external, internal and transaction; and further classified in the domain of infrastructure, learning facilitation and change management services. The qualitative data was obtained with various knowledge elicitation approaches. The approaches included interviewing Head teachers, ICT teachers and Circuit supervisors; focal group discussions, school observations, documents analysis, and video recordings of teaching and learning scenarios. The sources of the data were Seventeen (17) participation schools. The schools were selected were purposefully for the study from Sekondi-Takoradi Metropolis in Ghana; based on their locations. The locations were stratified into urban schools, peri-urban schools and rural schools.

2.4 Tool(s)

We used CmapTools for our ontology design. CmapTools, is an application for building concept maps. In the works of (Cañas et al., 2003), the effectiveness of the application in the context of education and training was identified; and found it relevant for our activity. Among many other valuable uses of CmapTools, it supports concept-mapping integration, supports collaboration and sharing of concept maps. It offers opportunity for visual representation of systematic hierarchy of concepts and patterns of linkages among concepts.

2.5 Analysis

On the rubrics for measuring, the DLS we used a binary scale to measure the status of digital services in schools per the grid data. We then computed the descriptive statistics of the services (see Tables 1, 2 and 3). Using the mean value of the services, we defined the status of the services activated within schools or otherwise; to inform comparisons to be made on the probable services ontology.

2.6 Initial DLS ontology

Using our services items relative to our conceptual architectural services ontology, we develop a schematic relation across all the services levels and classifications. We propose DLS ontology typified by inter-relation of equipment, tools, policies processes, and human actions that culminate into an enhanced DLEO for schools. We define the enhanced digital learning ecosystem of a school as system where digital learning services are adopted and used for learning engagements; which engagements is perceived as probable operations (“a” to “h”);

a) Digital learning resources for educational communication,
b) Digital resources as tools for teaching non-ICT subjects,
c) Digital resources as tools for student learning engagement and assessment,
d) Digital resources for school management and administration,
e) Educational software and applications for innovative teaching and learning,
f) Use of free and open digital learning resources,
g) ICT classes for developing student digital competences and
h) Online/virtual environment for teacher - student-learning activities

Based on conceptual architecture (Fig 1), we propose our initial concept map as the probable outcome of the semantic relations defining ideal services ontology for defining schools’ DELO (Fig 2, see appendix).

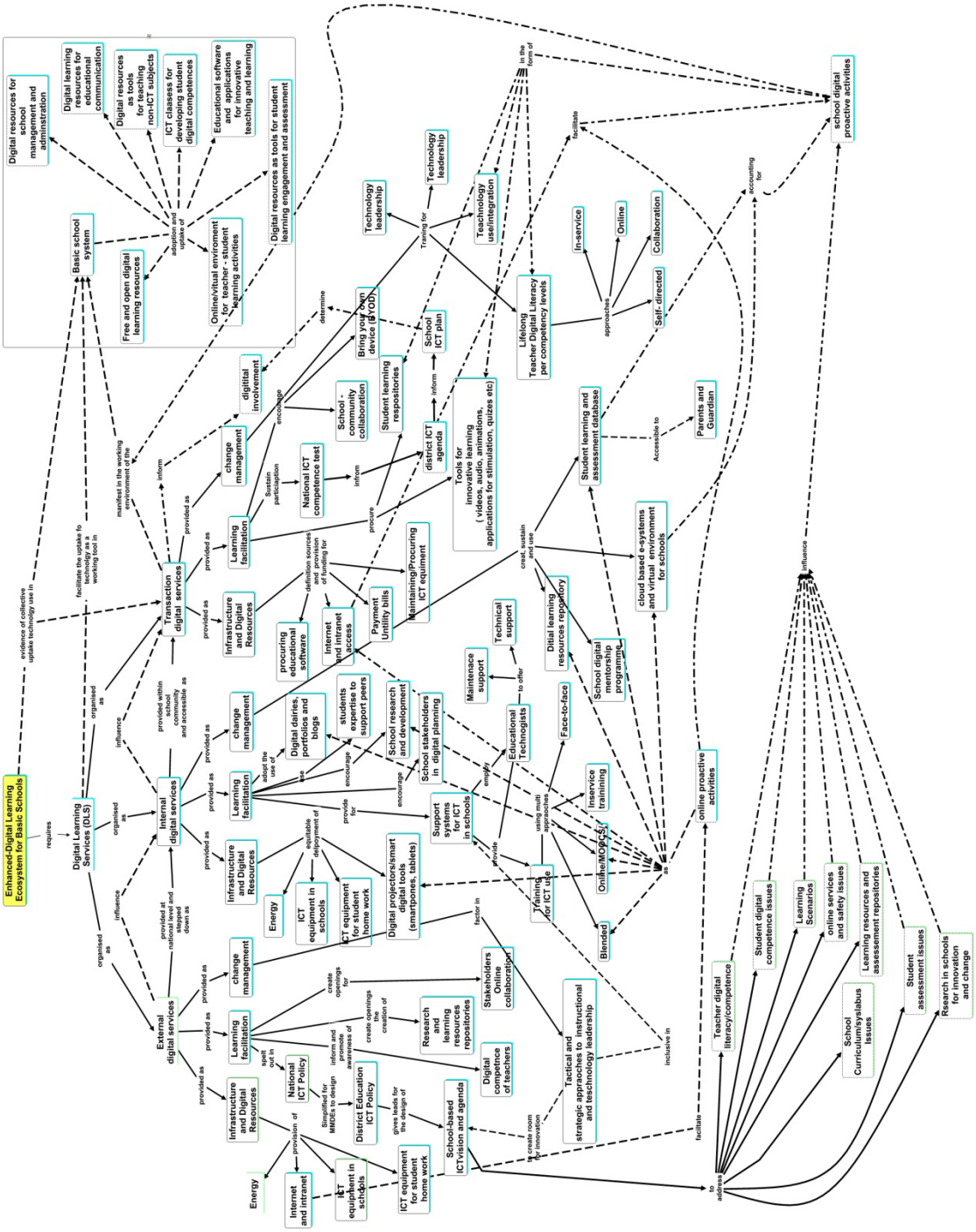

Figure 2. Conceptual representation of ideal DLS ontology for schools.

3 Results and Discussion

We extracted the DLS with relatively high means (M > .40) to represent the most prevalent services situation in the schools' DLEO. Tables 1, 2 and 3 show the descriptive analysis results of respective external, internal and transaction services; grouped as infrastructure, learning facilitation and change management services.

3.1 Infrastructure

External Services		**Internal Services**		**Transaction services**	
Service Group	***Service Items***	***Service Group***	***Service Items***	***Service Group***	***Service Items***
Infrastructure	*The electric power is permanently accessible to schools. (M = .88, SD = .332) *The government, municipality or /companies provide free ICT devices for individual teachers/students (M = .65, SD = .493) *Most of the students have ICT devices at home to do homework (M = .53, SD = .514).	**Infrastructure**	*The school uses has energy sources (electricity solar, wind, etc t power ICT devices (M = .88, SD = .332) *The ICT technology is located in fixed areas in the school (M = .41, SD = .507) *The school uses portable ICT technology (projectors, laptops, tablets, smart phones) (M = .71, SD = .47)	**Infrastructure**	*The school has to find resources and pay for having internet access (M = .71, SD = .47) *The teachers use internet with own devices and pay for it by themselves (M = 1.0, SD =.00) *The school has to find resources to buy devices for having wifi services in the school (M = .71, SD = .47) *The school is provided with the ICT technology for developing digital competences free of charge by the government/municipality/company (M = .41, SD = .507) *The school has to find resources for buying ICT technology they need for developing digital competences (M = .88, SD = .332) *The parents and teachers are responsible for buying ICT technology the students/teachers use in the class (M = .59, SD = .507)

Table 1: Descriptive statistics of infrastructure across the services.

Information from Table 1 shows that externally, some DLS in the form of infrastructure exist. These included electricity, access to ICT tools and equipment from either the government or the private institutions. As an internally service, the named external services were quite visible in schools. However, at the transaction services level, most of the schools were found wanting. One major setback in the schools DLEO was the absence of internet and wifi services. Almost all the schools had to grabble with the challenging of finding funding to provide effective ICT equipment, internet access, and payment of utilities bills. These factors constrained technology uptake in schools; as observed at the learning facilitation and change management practices within the schools.

3.2 Learning facilitation

In the analysis, it became evident that National ICT agenda/policy is put in place externally by the government (Table 2), School curriculum carved from the policy spells out procedures, method, and contents for teaching and assessing digital competences in schools. Internal services carved from external services were found in various forms of services in the school. For instance, ICT as a subject was taught in the schools; thus, students' digital competences are taught during computer classes and they participate in national ICT assessment for students. Services in schools however, were constrained by some factors – as alluded to in earlier discourse. Non-ICT teachers are unable to integrate technology due to lack of adequate resources and access to the internet. Again, the inability for system to have well-defined external services for teacher lifelong digital literacy training, definition of innovative learning scenarios and assessments, have translated into adverse digital services at the internal DLS level. For instance, none of the schools incorporated blogs, portfolio, and diaries among others in their learning activities. At the transaction services level schools lacked the capacity to be engaged in e-learning or online activities. They equally do not have digital repositories for assessment and learning resources; most computation of school based assessment (SBA) done manually. Our findings show schools seem to conducting learning activities more traditionally than using technology as supporting media.

External Services		Internal Services		Transaction services	
Service Group	***Service Items***	***Service Group***	***Service Items***	***Service Group***	***Service Items***
Learning facilitation	*MoE defines in the national curriculum the required learning outcomes for students' digital competences (M = .76, SD = .437). *National curriculum defines specific compulsory courses for learning digital competences (M = .65, SD = .493) *National curriculum defines the test- or exam-based evaluation for digital competences for students (M = .71, SD = .470). *National curriculum specifies learning ICT as a crosscutting theme to be taught by all subject teachers (M = .53, SD = .514). *National curriculum defines specific project courses where digital competences are integrated (M = .53, SD = .514) *MoE has set examples of student-centred assessment strategies and methodologies to schools in national curriculum (evidence-based, portfolio-based, progress-reporting, self-evaluation, peer-evaluation, self-testing) to be used in the teaching and learning (M = .53, SD = .514). *MOE or relevant national body defines quality criteria for digital learning scenarios (M = .41, SD = .507) *Private companies provide repositories of learning resources (M = .53, SD = .514) *MoE or relevant body provides free basic level trainings for digital competencies to teachers (internet, office tools - tools for creation and information literacy) (M = .47, SD = .514). *MoE/municipality/University/research groups collects data from the schools and analyses at national, regional, municipality level (M = .65, SD = .493).	**Learning facilitation**	*The school has computer class (es) (M = .88, SD = .332) *There is access to school's ICT technologies for work/lessons/homework when it is needed (M = .41, SD = .507) *The teachers voluntarily provide ICT support to other teachers about designing learning activities (M = .65, SD = .493) *The students' digital competences are taught in ICT lessons (M = .94, SD = .243) *The students' digital competences are tested (exam or test) (M = .94, SD = .243) *The students' digital competences are taught mainly by subject teachers (M = .82, SD = .393) *The students are required demonstrating ICT competences as part of the project work (M = .88, SD = .332) *The students in the schools collect digitally the learning-related evidences ((portfolio, diary, folder, blog etc)) (M = .53, .514) *The teachers provide in subject teaching digital learning activities that address factual knowledge (M = .59, SD = .507) *The students are taught mainly about how to use basic office software and internet (M = .88, SD = .332) *The teachers use in subject teaching digital learning activities that address problem-solving in socio-technical contexts (M = .41, .507) *The teachers use in subject teaching digital learning activities that address creativity and innovation (M = .65, SD = .493) *The teachers use in subject teaching collaborative digital learning activities (M = .47, SD = .514) *The teachers develop digital learning scenarios for their students (M = .53, SD = 514) *The teachers develop digital learning resources for their students (M = .65, SD = .493) *The teachers make use in their lessons of digital learning activities and -resources developed by other teachers (M = .59, SD = .507) *The teachers use in lessons simultaneously different digital activities/ resources to personalize and differentiate learning according to their students' needs (M = .59, SD = 507) *The school organizes digital learning process into the traditional lessons (M = .71, SD = .47) *The digital teaching process takes place mainly in the classrooms (M =.76, SD = .437) *The teaching with digital devices takes place mainly in the computer class (M = .88, SD = .332) *The school has some innovative ICT technologies for supporting learning (M = .47, SD = .514)	**Learning Facilitation**	*The school supports bringing own devices to lessons for learning digital competences (M = .76, SD = .437) *The school has to find resources to use the digital services for maintaining students' learning data (M = .76, SD = .437) *The school has to find resources for paying teachers/students access to the e-learning environments that are used for conducting lessons (M = .53, SD = .514) *The school has to find resources to buy the educational software or web services the teachers request for their lessons (M = .65, SD = .493) *The teachers in the school complement and accommodate the national curriculum and subject syllabi with additional digital learning outcomes and activities (M = .71, SD = .47) *The school participates in national exams/tests set by MoE to evaluate students' digital competences (M = .71, SD = .47) *The teachers share digital learning scenarios they created with other teachers digitally (school list, shared folders, shared school repository, teaching blogs) (M = .53, SD = .514) *The schools maintain externally shared activities with other teachers and schools through the circulation of digital teaching ideas and -resources between teachers and students (workshops, webinars, school visits, conference, networks, counselling etc.) (M = .47, SD = .514) *The teachers share digital learning resources they created with other teachers digitally (M = .71, SD = .47) *The school has to find resources to access to creative tools, games and various multi-media learning resources (Video clips, Audio files, Photos, Illustrations, Animated activities, Worksheets, Quizzes, Tests, Voting activities) (M = .71, SD = .47)

Table 2: Descriptive statistics of Learning facilitation indicators and activities across the services.

3.3 Change management

In the attempt to create and sustain any form of digitally enhanced learning environment in the schools, the dynamisms of technology in schools were taken into consideration. This dynamism fuels influence on innovation in schools. There change management services were deemed essential for managing innovation and stimulating it as well in schools. Table 3 shows prevailing change management practices in schools. Externally, regulations exist for data collection in schools for research and innovation purposes.

External Services		**Internal Services**		**Transaction services**	
Service Group	***Service Items***	***Service Group***	***Service items***	***Service Group***	***Items***
Change management	*The national accreditation of teacher professional levels accepts presenting digital development portfolios and evidences (M = .47, SD = .514) *MOE or relevant national body defines quality criteria for training teachers' digital competences (M = .41, SD = .507) *Private companies offer paid ICT courses for teachers that end with certificates, licenses (M = .65, SD = .493). *The subject- or practice-related professional online teachers' networks are active in the country (M = .41, SD = .507) *The subject- or practice-related professional online networks are active internationally (M = .65, SD = .495) *There is a national ICT agenda regulating digital competences, learning and innovation (M = .59, SD = .507) *MoE/Municipality sets regulations on purpose/frequency and methods on data collection in schools (M = .59, SD = .507)	**Change Management**	*Someone in school has paid tasks to manage ICT technology in the school systematically (M = .47, SD = .514) *The school has formalized ICT usage rules and regulations (M = .59, SD = .507) *Staff and students follow the ICT usage rules and regulations (M = .65, SD = .493) *The school has developed and maintains ICT vision and agenda(plan) (M = .71, Sd = .47) *The skilled students are recruited in mentoring teachers and other students about ICT usage (M = .41, SD = SD = .507) *Teachers plan and monitor their professional development using digital software (portfolios, diaries, blogs) (M = .41, SD = .507) *The teachers in the schools collect digitally their learning-related evidences (portfolio, diary, folder, blog etc) (M = .41, SD = .507) *The educational technologist provides in-school instructional support for teachers (couching, peer reviews, informal group meeting, workshop and etc.) to develop their digital competencies (M = .53, SD = .514) *The experienced teachers provide in-school instructional support for teachers (couching, peer reviews, informal group meeting, workshop and etc.) to develop their digital competencies (M = .47, SD = .514) *The educational technologist provides in-school instructional support for teachers (couching, peer reviews, informal group meeting, workshop and etc.) to introduce new approaches in digital teaching and learning process (M = .53, SD = .514) *The school uses practices to aid internally in the school the circulation of digital teaching ideas and -resources between teachers and students (open classes, peer-learning events, demonstrations, competitions etc.) (M = .41, SD = .507) *Teachers participate at basic level trainings for digital competencies (internet, office tools - tools for creation and information literacy) (M = .88, SD = .322) *School administrators, IT managers and educational technologists (or school teams) participate at trainings for school level digital innovation and organizational change (M = .65, SD = .493) *Subject teachers participate at trainings for teachers about subject related digital competencies (M = .59, SD = .507) *The school constrains teachers' professional learning to be relevant to the curriculum requirements and school strategy (M = .41, SD = .507) *The school plans ICT policy to contribute to the school's development strategy (M = .53, SD = .514) *The school leadership together with school community (board of trustees, teachers, students) plans for ICT policy (M = .59, SD = .507) *The new requirements for digital innovations are developed in the joint participation of leadership, It support, teachers, students and parents (M = .47, SD = .514) *School's ICT policy defines ICT contribution to the curriculum and the teaching and learning approaches with ICT (M = .71, SD = .47) *School's ICT policy defines digital devices, e-system and digital resource management, e-System utilization (M = .41, SD = .507) *School's ICT policy defines ICT utilization monitoring and evaluation, assessment and reporting,	**Change management**	*The school has to find resources for paying for IT support for maintaining school ICT technology (M = .82, SD = .393) *The teachers in the school consider some students' digital competence scales (ISTE framework, 21st skills framework or other similar) when developing subject syllabi and tasks (M = .47, SD = .514) *The teachers in the school consider some teachers' digital competence scales (ISTE framework, 21st skills framework or other similar) when planning their professional development (M = .71, SD = .47) *The teachers frequently participate in online professional networks about digital teaching innovations(M = .41, SD = .507)

			Monitoring and review of academic progress (M = .59, SD = .507) *School's ICT policy defines Staff professional development and training issues (M = .47, SD = .514) *School's ICT policy defines Internet safety issues, netiquette (M = .65, SD = .493) *School's ICT policy defines strategy for ICT implementation, Continuity and progression (M = .71, SD = .47) *The schools collect and analyzes data to monitor academic progress and make corrections (M = .71, SD = .47) *The schools collect and analyzes data to monitor organizational change and make corrections (M = .59, SD = .507) *The school collects and analyses data to coordinate teachers' professional development (M = .53, SD = .514) *The school follows privacy and safety regulations on digital data maintenance (M = .47, SD = .514)		

Table 3: Descriptive statistics of change management indicators and practices across Services.

Again, externally, teacher professional networking associations were found to be available either nationally or internationally. As an external DLS, national ICT agenda defines student and teacher ICT competences for digital literacy and innovation in schools. There are openings for teachers to acquire these digital competences from private organisations - as paid services. The external DLS seems to create digital opportunities directed towards the schools. Visit to schools revealed that school ICT agenda appear to be unwritten policy, which is adhered to based on prevailing school situations or learning scenarios. Stakeholders in school consider the undocumented school ICT policy/agenda as their guide. However, at the grassroots level these beliefs turnout not to be commanding compliance enough in schools. Teachers desired to be digitally literate and innovative yet various factors inhibit their prospects. Paramount is funding; funding digital learning practices in most of the schools is next to impossible. It is worth noting obstacle to generating innovation and change in schools is deeply rooted in the external DLS. For instance, externally(DLS) at the national level there appears to be no clear definition of what levels of digital or ICT competencies teachers require for their professional practice and development and practice. As observed, during teacher appraisal for promotion or managerial/administrative progression, evidence of digital literacy or competencies is not strong requirements. Teachers' digital diaries, portfolios, certification as evidenced of digital competence attainments is actually not a major requirement in teacher progression or professional practice. Therefore, the urgency for teachers to embrace the new professional paradigm of technology integration seems derailed; because practically, the system seems not appreciate the essence of this kind of school activity.

From the descriptive statistics of the services (Tables 1, 2 and 3) we modeled schools' DLEO on the services ontology, as presented in Fig 3 (see appendix). On the services ontology the opportunities and challenges resulting from the DLS are visualized. The opportunities across the DLS are the highlighted concepts; whiles, constraints as represented as concepts with broken lines around them. Other services with the potential to enhance schools' DLEO are also presented as concepts, but, with continuous borders and without highlights. Relying on the merits of CmapTools the semantic relation of the all the services we visualised in the form of Cmaps – depicting our service ontology. The status of schools' DLEO is mapped on the service ontology, based on the DLS performance in schools (Tables 1, 2 and 3). In the final analysis this study confirms a similar done with the same sample; that lack of various services capable of enhancing the DLEO of the schools constraints the schools from exhibiting proactive use of DLS(Quaicoe et al., 2016). In sum, schools require more support to pass the "digital service barometer" advanced as the services ontology from this study.

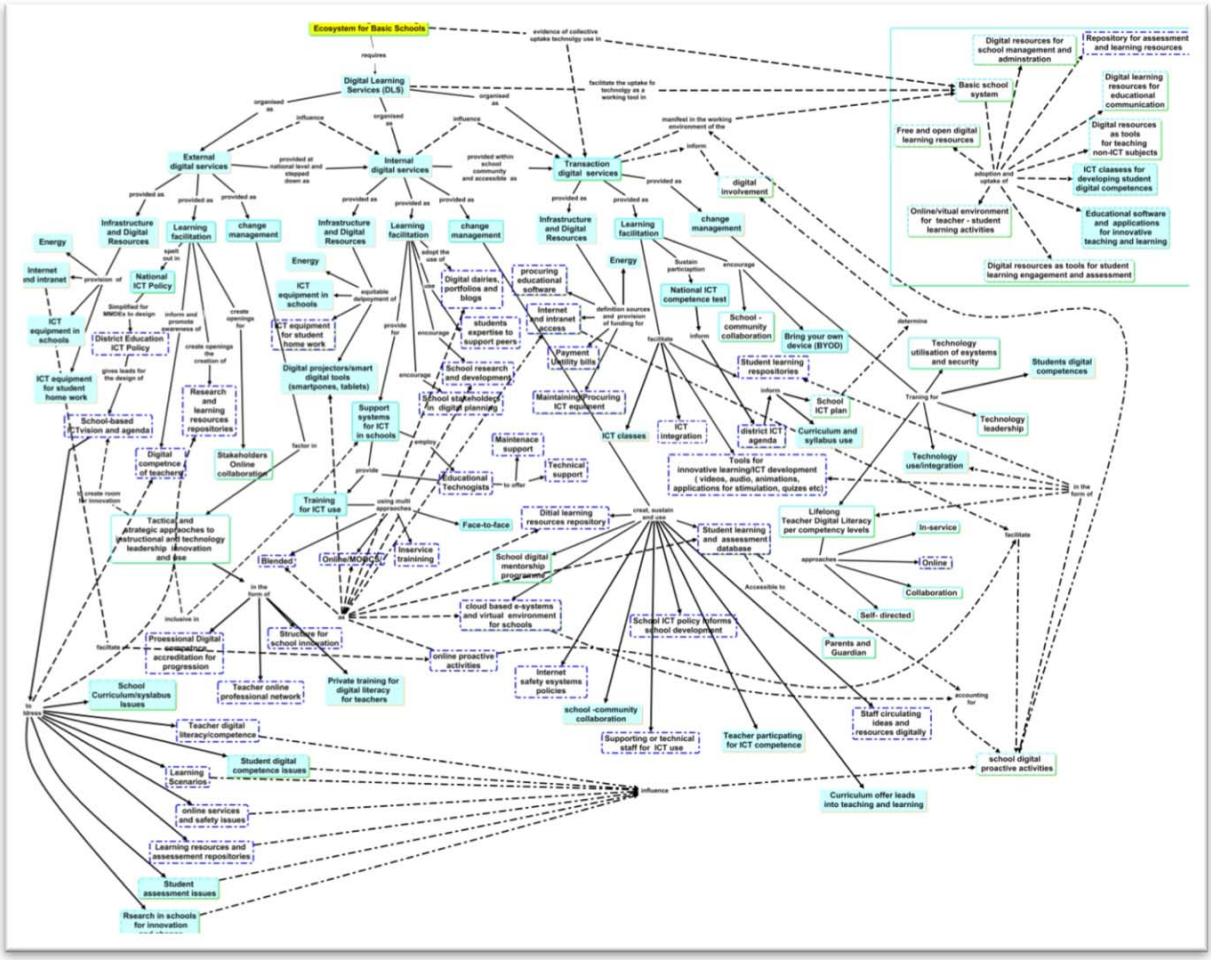

Figure 3. Schools DLEO as defined by the DLS ontology.

4 Conclusion

In this study, we used concept maps to develop DLS ontology. The results indicate that across schools generally lack structures for digitally enhanced activities. The overall outcome suggests that many services in schools are missing the services ontology; causing school not to exhibit an enhanced DLEO. However, the result indicates limited key digital practices in schools are take place: they are organsied around 1) ICT classes and 2) use of Laptops/Smart devices in limited cases to facilitate learning. We propose to stakeholders in charge of school development, to use DLS ontology (Fig 3) as guide to discuss the possibility of maximizing DLS in DLEO.

5 Acknowledgements

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