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Data Driven Quality Improvement of Health Professions Education: Design and Development of CLUE – An Interactive Curriculum Data Visualization Tool

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Abstract. Curriculum Mapping and dynamic visualization is quickly becoming an integral aspect of quality improvement in support of innovations which drive curriculum quality assurance processes in medical education. CLUE (**C**urricu**lu**m **E**xplorer) a highly interactive, engaging and independent platform was developed to support curriculum transparency, enhance student engagement, and enable granular search and display. Reflecting a design based approach to meet the needs of the school's varied stakeholders, CLUE employs an iterative and reflective approach to drive the evolution of its platform, as it seeks to accommodate the ever-changing needs of our stakeholders in the fast pace world of medicine and medical education today. CLUE exists independent of institutional systems and in this way, is uniquely positioned to deliver a data driven quality improvement resource, easily adaptable for use by any member of our health care professions.

Keywords. Curriculum mapping, visualization, design based approach, online interactive map, searchability functions

1. Introduction

In Medical Education, and increasingly in higher Education in general, curriculum mapping has become an essential component of curriculum integrity, serving many purposes for multiple stakeholders. For example, it enables (i) learners to dynamically track their progress and thus promote transparency of the taught curriculum, (ii) educators to maintain perspective with respect to the alignment of the curriculum with intended outcomes, and (iii) administrators to more effectively manage the quality assurance mandate [1]. There are few examples in the literature of detailed curriculum mapping tools, despite their prevalence in use in Medical Education. One example is LOOOP, a curriculum mapping tool that was developed to map, plan and accredit 22 competency based courses across Europe, Africa and Asia [2]. This mapping process was developed using 4 out of the 10 windows described by Harden [1], namely outcomes, content, learning opportunities and assessment. Although some curriculum mapping

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tools are in use in many medical schools, they don't exist independent from underlying institutional technological environments which limits their use in other contexts. Furthermore, the data is not structured in a manner that complies with existing technical standards which therefore doesn't allow the sharing and benchmarking of curricula across different curriculum mapping systems. The aim of this project is thereby to design and develop a new bespoke curriculum mapping system that addresses both stated shortcomings. The targeted system is named CLUE.

2. Methods

2.1 Mapping the Curriculum

A bespoke outcomes based curriculum was developed for a systems based undergraduate MBBS programme. Learning outcomes were developed (along with the relevant learning material) which were aligned to the UK's General Medical Council (GMC), the Singapore Medical Council (SMC) and the Accreditation Council for Graduate Medical Education (ACGME). The day to day learning opportunities along with specific learning outcomes and learning resources over two years were developed *de novo* and captured in the iLKC (Compass) suite, allowing students and faculty alike to navigate a digital learning environment throughout the 5 years of their undergraduate curriculum [3]. For the purpose of this report we are focusing on the first two years of the undergraduate MBBS curriculum. No previous curriculum mapping system was in place, and the intended use is for research, curriculum development and quality improvement purposes. The stakeholders currently utilizing this system are medical education researchers, faculty, students and senior management. The curriculum is mapped to three overarching themes which span across 5 years (see Figure 2), with greater emphasis on each theme as the student's progress through the appropriate stage of learning and training, Theme 1: Scientific Basis of Medicine, Theme 2: Clinical Management and Patient Centred Care, Theme 3: Healthcare Delivery and Professional Standards. Underpinning these themes, especially in the early years, are horizontal and vertical courses focusing primarily on Integrated Science in a Medical Context. A course such as Human Structure and Function spans the majority of year 1 and year 2 and is comprised of blocks of time (teaching blocks, a total of 8 across the first two years) devoted to human body systems, e.g. the Cardiorespiratory system. The Cardiorespiratory block is subsequently divided into various topics and so on. Each individual topic e.g. Haemorrhage, has multiple learning outcomes related to the curriculum. Each learning event is mapped to the fundamental units of our curriculum, e.g. anatomy, communication, disease investigation. In addition, each learning event is mapped to an appropriate mode of assessment. The final layer of mapping is the alignment of learning opportunities to governing frameworks, e.g. GMC, SMC and ACGME, to ensure our taught curriculum maps to desired graduate outcomes and competencies.

2.2 Approach to Design and Develop the Curriculum Mapping System

To ensure the most effective design and development process a design based approach was adopted [4]. Stakeholders were encouraged to provide regular input on how best to (i) visualise the data and (ii) deliver the required functionality. Using this interactive and

iterative process, our current curriculum mapping tool CLUE, or Curriculum Explorer, emerged. CLUE draws upon the curriculum materials already defined by our school, existing as a mapped dataset within iLKC. The suite supports the curriculum management of learning outcomes, targeted learning resources and timetabling of associated learning activities within each teaching block across the years. Each of these components has its own designated database (See Figure 1). Data from each of these databases is transferred and stored in a data warehouse. The curriculum mapping tool (CLUE) then draws the transformed data from the data warehouse, and enables subsequent tracking of changes to outcomes, resources etc.
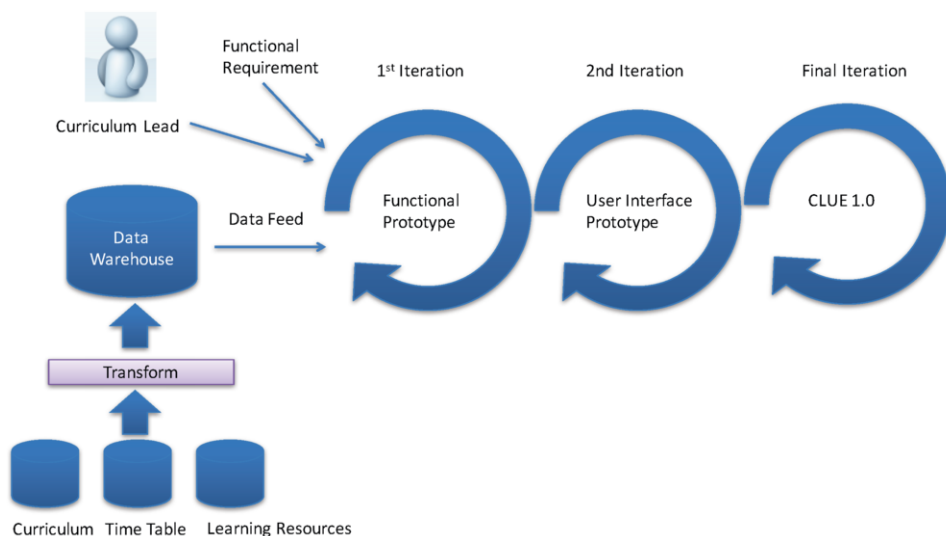

Figure 1. Iterative systematic design of CLUE.

    Figure 1. Curriculum, Timetable and Learning Resources data is transformed and migrated to the data warehouse. Curriculum and Technical Leads devise the functional requirements. The data are fed into the first iteration, a function prototype, which is modified to become the user interface prototype (2nd iteration) which ultimately culminated in the final iteration, CLUE.

3. Results

3.1 CLUE Visual Explorer

Here we describe the generation of CLUE, focusing on the first two years of an undergraduate MBBS programme, and we describe the searchability and mapping functions of this dynamic and interactive resource. CLUE can be visualized via multiple paths depending on the level of the curriculum being interrogated. One main path is via an inherited mode, where one navigates through the curriculum starting at the top of the

hierarchy, i.e. Theme level, and proceed through the underlying Fundamentals and relevant Domains, as demonstrated in Figure 2 A. The same type of search can be completed in a non-inherited mode simply by clicking on the desired domain, e.g., Anatomy. Either approach will highlight all areas in the curriculum, and all learning events where Anatomy is taught across the years. The user can then review the learning outcomes and learning resources specific to the Anatomy topics highlighted, as well as the mode of assessment relevant to that learning activity. A complementary approach to visualising the curriculum is to search by year, by course, or teaching block etc. and to manually trace through the curriculum in a hierarchical manner (Figure 2 B). Alternatively, a *free text search* function allows the user to narrow in on any topic of interest, e.g. Blood Gases (Figure 2 C).
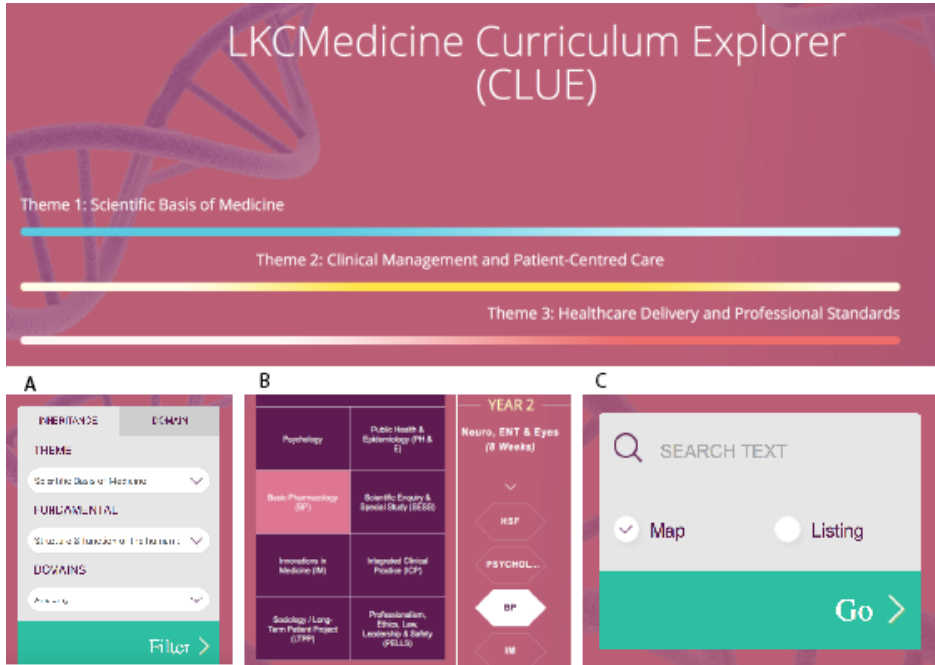

Figure 2. The various exploration paths of CLUE

Figure 2. The curriculum Themes, Fundamentals and Domains can be searched in a hierarchical manner (Figure 2A). Alternatively, by searching by year (e.g. year 2) one can search the courses taught in year 2, e.g. Basic Pharmacology, and all the areas where Basic Pharmacology is taught will appear as highlighted icons (Figure 2B). Lastly, an open text search allows you to search the curriculum by free text (Figure 2C).

4. Discussion

We have developed a curriculum visualization system (CLUE) that supports future iterations tailored to our specific shareholder's needs. CLUE enables the user to navigate through each of the 5 years of our curriculum via multiple paths. For example, by

choosing a particular year, the courses taught within that year are immediately visible. In the same manner, it is also possible to view where integrated courses are taught throughout and across the years. Our curriculum is comprised of three Themes, and the curriculum mapped can then be viewed at the level of each these Themes, the underlying curriculum Fundamentals and learning Domains, in a hierarchical manner (e.g., Theme 1>Scientific Basis of Medicine > Fundamental > Structure and Function of the Human Body in Health > Domain > Anatomy). In this manner, the user steps down through the curriculum hierarchy and arrives at a granular display of all the learning outcomes that are mapped to Anatomy. Alternatively, the user can choose a course, e.g. Basic Pharmacology (BP), and see via highlighted areas where, across the years, Basic Pharmacology is taught. In an individual teaching block, e.g., the Neuro, ENT, Eye (NEE) teaching block in year 2, the user can click the BP icon and it will show all the learning outcomes related to Basic Pharmacology and relevant to the NEE teaching block. Clicking any of the displayed learning topics will lead to the full display of the learning outcomes, the relevant assessment mode, and how this topic has been mapped to curriculum Themes, Fundamentals and Domains. Finally, this learning event is also mapped to the outcomes of multiple competency frameworks, namely the GMC, the SMC and the ACGME. An additional feature of CLUE is a search function by free text, which enables the user to search the curriculum, for any free text content, e.g., if one were to search for "Blood Gases", one would be taken to all the courses across the five years where Blood Gases are taught. CLUE builds on an iterative and dynamic process to reflect and support the fast pace of curriculum change in medicine today. As the curriculum evolves, occasioned by reviews of accreditors, and modifications to competency frameworks, so too must CLUE. CLUE must be adaptable and easily modifiable if our multiple stakeholders are to use the tool to identify changes to Outcomes, associated Learning Resources and the variety of Assessments internal to the successful training and development of our trainee doctors. In this manner, and with these attributes, CLUE forms part of an innovative and exciting research approach to curriculum design development and programme evaluation in Medical Education.

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