Abstract
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Curriculum mapping of an outcomes-based programme using a database was developed using a relational database structure, and it functions as a searchable database by the use of keywords. Factors such as the framework of the programme, the database entity relationship diagram (ERD), benchmarking, terminology and nomenclature, analytics and integration with the learning management system requires careful consideration before implementation. Built into the structure of the curriculum database are the analytics features which identifies the curricula data using defined keywords. This enables staff and students to search through any programme or subject of interest to track a subject or keyword to the point of delivery with the use of the analytics feature. This results in the curricula information being transparent for all stakeholders, ensuring curriculum mapping and blueprinting of assessments are readily available.

This paper reports on the implementation of a university-wide curricula database which includes multiple undergraduate and postgraduate programmes, including chronological versions of a programme at an institution with diverse health professions programmes, including medicine, dentistry, pharmacy. Additionally, this paper outlines the steps to design the curricula database, the development of the framework of the database and the analytics, the challenges in implementation, the results that can be obtained from such a database and the lessons learnt.

Keywords
Curriculum map, analytics, building a curriculum database, search
Introduction
Outcomes-based education (OBE) is a way of “designing, developing, delivering, and documenting instruction in terms of its intended goals and outcomes” (Spady, 1988). This performance-based approach to curriculum development coupled with constructive alignment between the curriculum, delivery and assessments, necessitates a requirement to track, map, and identify the evidence of a particular lesson that has been planned, delivered and assessed in the curriculum (Biggs, 1996). Challenges in tracking the curriculum have suggested an urgency in developing a tool that allowed the stakeholders to access information for an OBE curriculum (Harden, 2001).

Many tools have been proposed to support curriculum mapping. One of the first reported databases for a medical curriculum came about in 1997 and was from the College of Medicine at the University of Iowa (University of Iowa, Health Care, Medical Curriculum Repository, 2017). This database was organised by course and the search was done by subject and keywords. A curriculum database is generally regarded as an electronic repository of a curriculum (Mattern et al., 1992). The database is an essential tool to organise large amounts of data, especially a curriculum, which contains information on outcomes, objectives, teaching and learning activities, credit hours, themes, topics and student learning time, amongst the many elements in the OBE curriculum (Friedman, 1995). Another widely used curriculum database in North American medical schools is the CurrMIT (Salas et al., 2003).

Currently, there are many software applications that can be used for curriculum mapping, and they are in the form of a spreadsheet, or a database (Curriculum 21, 2009-2017; Entrada Consortium, 2017; Lifupp, 2017). Databases are the preferred solution for curriculum mapping as they are capable of organising data into fields and records and are designed for data management (Masters, 2018). These curriculum mapping software applications are usually integrated with other student learning tracking capabilities such as portfolios, timetable scheduling, learning management system, and assessment tracking as well as student feedback. These features are built into the mapping software and may not be configurable or may not be what the end user needs. Curriculum mapping must meet the needs of administrators, faculty and students as well as support the needs of initiatives such as continuous quality improvement, curriculum renewal, accreditation, support of curriculum committees, reports to accreditation committees, and medical education research. In light of these requirements, we have built a curriculum map based on these requirements and needs at our institution which offers diverse health professions programmes at both undergraduate and postgraduate levels.

Methods
Although there are many commercially available solutions to support curriculum mapping, a purpose-built application was identified to be more useful for our institution, the International Medical University (IMU) in Kuala Lumpur.

Phase 1: Planning the Curriculum Database Structure
The following decisions were considered first as they affected the entity relationship diagram (ERD) of the database, which was crucial to the curriculum alignment framework built to support the search and analysis functions (Biggs, 1996) (Table 1). User needs obtained from curriculum administrators and faculty members were included in the decisions. The seven decisions made at International Medical University were as follows:

- Framework of the curriculum structure: A constructive alignment framework was used, where the intended learning outcomes were aligned with the teaching/learning activities and the assessments.
- Database Type: A relational database structure was used to enable both vertical and horizontal integration of the curriculum which allows for searching capabilities using the constructive alignment framework.
- Requirements for Benchmarking: Benchmarking of the outcomes with accreditation bodies standards.
- Define terminology and nomenclature: A standardised terminology and use of terms throughout the curriculum database was established.
- Analytics functionality: Ability to perform data analytics to analyse curricula details and display in a graphical form, including tracking and dashboarding.
- Capacity for Integration: Enable links to the current learning management system and the ability to import and export data.
- User training and support documentation: Periodic user training and online support documentation was provided to ensure that users are supported.
The IMU experience:
The first four decisions (above) resulted in a consistent relational database design. As a result, the database was easier to perform analytics on as the relational database structure was able to link the outcomes, delivery and assessments in the curriculum map/database. Such mapping can be achieved using a spreadsheet, but spreadsheets are essentially a two-dimensional grid where the rows and the columns of the spreadsheet are linked together in table. Curriculum maps generally correlate far more complex relationships and for the example of constructive alignment for Course Objectives to Teaching and Learning to Assessments; there should be at least three tables to link all the three relationships. Such spreadsheets will become exceedingly complex as there are many numerous Course Objectives, Teaching and Learning activities and Assessments for a single course. Imagine the spreadsheet being used for a programme with multiple courses over 8 semesters (or even more); the spreadsheet requirements can be complex with multiple use of rows and columns to map the relationships.

In this case, the database is the preferred solution as it is a collection of related tables (like in a spreadsheet) which is linked together in an entity relationship diagram (ERD). A database can manage large amounts of data and the relational database allows one point of change for data that share the same information. For example, programmes that share similar institutional outcomes, if there is an institutional or accreditation need to change the outcome that is shared by these programmes, there need only to change it once from the database point of view. Similarly, there are many shared descriptors or elements for the curriculum, in which the one point of change for the relational database will result in less errors, mishaps and omissions in the tracking of changes to the curriculum since duplication is kept at a minimum.

Data modelling of the curriculum requires a thoughtful process of organising the curriculum into entities (tables) and attributes (columns), which is the database terminology for what is normally tables and columns in the spreadsheet (Figure 1). Databases are a collection of records or data and there are currently several ways of managing these data - and the database system is usually named after the way it manages the data.

Curriculum data for any educational programme following an outcomes-based objective typically can be separated into the objectives/outcomes, delivery of the teaching and learning and the assessment. There is an inherent relationship between these three areas as established in constructive alignment and changes in any one of the areas will impact the other two. In other words, the curriculum structure for an outcomes-based programme should best be constructed as a relational database where separate tables of data are linked with one another through a relationship. In Figure 1 the table on the left lists the rows and columns of a spreadsheet or the records and fields of a table in a database. Tables are all inter-related with a defined relationship so that table 1 can refer to information on table 2 and vice versa. Multiple types of data including updated revisions of data in the curriculum can be maintained in the tables: The table on the left illustrates old data in rows 1 and 2, whereas rows 3 and 4 are the updated curriculum data and they reside on the same database table.

Database Application Development:
The steps on developing the application was based on the steps listed in Table 2 (Perez, 2016). These steps include an analysis of the needs and establishing project management approach. The steps are listed in Table 2 are self-explanatory and identify the questions the project team needs to ask themselves.

The IMU experience:
All the five steps listed in Table 2 were considered, albeit not necessarily in the sequential order listed here. The needs analysis and coverage of requirements will normally require the input of IT literate faculty or better still Information

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Table 1. Constructive alignment framework used for the framework of the curriculum map

| Teaching-Learning Activities | Intended Learning Outcomes | Assessment Tasks |
|-----------------------------|----------------------------|-----------------|
| Create a learning environment using teaching-learning activities that address the verb and therefore are likely to bring about the intended outcome. | Describe the intended learning outcome in the form of a verb/learning activity, its object (the context) and specify the context and a standard the students are to attain. | Use assessment tasks that also contain the verb, thus enabling the assessor to judge with the help of rubrics if the students’ performances meet the criteria. |
| Activities can be:          | University Graduate Attributes Accreditation Body Learning Outcomes Programme Learning Outcomes Module Learning Outcomes | Assessments are both formative and summative, where the former is used for feedback and latter for progression. |
| 1. Small group              |                             |                 |
| 2. Large group              |                             |                 |
| 3. Teacher-centred          |                             |                 |
| 4. Student-centred          |                             |                 |

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Technology Services department or developers. At this stage, one must be very clear for what the goals of the database is for. This can be a confusing time as there are goals which are must haves and those which are good-to-have and usually they differ between different users of the database. The accreditation needs will usually be different from the teaching faculty’s needs as well as for the students. Having a very clear idea of the goals will assist this step. In our experience, we considered the needs of everyone who will have access to the database: namely the university quality processes (accreditation), the teaching and learning delivery team (faculty), and the users (students). These categories will have an impact on the user rights in accessing the database.

Historically, the database began its life mapping a single programme and had evolved its various database tables, relationships, curriculum descriptors and functionalities for the BSc. Pharmacy (Hons) with one of the authors as the developer. The functions and needs of the database grew ‘organically’ as the needs of the programme grew and only was the opportunity to include the curricula from other programmes was taken. Even though the curricula database was an in-house development, the steps listed under Table 2 was necessary at each stage of its growth.

**Phase 2: Development**

**Setting Ground Rules**

Commercial curriculum mapping software have standardised name fields which may be difficult if not impossible to change, and during the initial planning phase for the project, the five ground rules set were:

- Common curriculum descriptors were to be used for all programmes and systems,
Unique curriculum descriptors for a minority number of programmes may be used if necessary,

The smallest unit of measure for any programme is the teaching and learning delivery (the curricula database is a collection of teaching and learning activities),

All items under (3) can be mapped in the architecture of the curriculum and nested under modules, programmes, assessments, accreditation domains, competencies, teaching and learning activities, outcomes, and references/reading list,

A search through any of the curriculum descriptors in (4) can derive any of the other linked descriptors (See Figures 2, 3, 4)

With the above ground rules, there were several factors to consider in planning for the database.

The curriculum map developed with the above considerations can be used to track individual programmes and courses/modules as well as individual lessons, and can also track multiple programmes including different versions of the same programme (Kang, 2012). For example, the original curriculum information for many programmes are retained in the database and each time the programme or even a single module/course undergoes a revision, the database is updated and is able to display the original curriculum and the updated curriculum. In the example that appears in Figure 2, 3, 4, the table displays the Pharmacy 2012 and 2017 curricula. This capability allows the database to track any changes and to also identify which cohort of students have been exposed to which revision of the curriculum. Additional examples on this is displayed in Figure 3. At the IMU, the curriculum map is known as the curricula database and it involves all the undergraduate programmes (12) in the university and tracks 109 separate database fields, of which 58 of them are curricula descriptors. The database was also contextualised to the IMU’s and the Malaysian Accreditation Board requirements such as the Code of Practice for Programme Accreditation (COPPA) for the cognitive, affective and psychomotor domains and soft skills (Malaysian Qualifications Agency, 2007).

It is capable of tracking any keyword, or term and map it to outcomes, teaching learning methods, curricula content and assessment tools. Other than blueprinting assessment tools to learning outcomes, the database allows for blueprinting of Malaysian Qualification Agency accreditation COPPA domains to components in the curricula for each programme. Reference materials including books, websites and e-learning links can also be included and tracked across the various programmes.

![Figure 2](image-url)  
**Figure 2. Example of mapping in the curriculum database between a lesson/topic with the learning domains and programme outcomes**
The IMU Experience:  
The route IMU had taken was for a rapid development of the database application based on the FileMaker platform (www.filemaker.com). This platform allows for the user to develop customised solutions with either available templates or using a ground up approach in creating the database. Health professions (education) faculty’s expertise does not usually include application development, and typically, most staff have a general understanding of spreadsheets, presentation tools, and word processing. The decision at that time in early development of the database was to look for a rapid development database application system which worked both on the Windows and Macintosh platforms, which could be grown as the need arises and uses a graphical interface. The development of the database would be conducted by a single faculty whose requirement were originally driven by the needs to track the various teaching and learning activities for accreditation purposes and later for student revision and faculty tracking of the curriculum. These activities should also be searchable using key words or via natural language. An additional advantage was that the search results can be arranged, filtered or sorted and this feature was provided by the FileMaker platform.

Additional requirements were that it is a stand-alone application which could be assessed from the web browser (for users) and that the database could also grow in complexity with additional functions, graphics, search and analytics functions, and integration to the Learning Management System. This database/curriculum map also provided links to the location of the teaching and learning material residing on the LMS and this includes resources for formative assessments.

Phase 3: Database Mining and Graphical Output
The curricula database had embedded analytics functions where the search results can be analysed and sorted using any function or fields to give comprehensive details (Table 3). It addresses the issue of making the curricula transparent to the students, faculty and administrators. It can generate reports for mapping of the curricula to outcome descriptors and this leverages on the capabilities of a relational database. This database enabled individual tracking of fields within a programme as well as the ability to track keywords or topics which may be taught across programmes (eg. identifying
how ethics and professionalism is delivered by different programmes). Such mapping helps staff and administrators during the accreditation and curriculum review processes, and since access of curricula map is through the cloud, everyone in the university including students can view the map. Additionally, the relational structure of the database allows staff from different programmes to look for opportunities to conduct common learning as well as inter-professional learning, thus maximising the use of scarce resources. Figures 2, 3, 4 illustrates an example where the database was mined to show a mapping between a lesson/topic with learning domains and programme outcomes. In Figure 3, the top diagram illustrates a typical view of the database, which the dropdown box allows a selection of various programmes, including different revisions of the programme. Here, Biomedical Science, Pharmaceutical Chemistry, Pharmacy, Dentistry and Medical Biotechnology have various versions of their programmes which can be tracked. Selection of the Programme will then allow the user to select the list of modules available (bottom left) and following that, the user can sort the list of teaching and learning activities into a table as shown in the bottom right. In Figure 4, the top diagram illustrates how another search can be initiated. From the topic or other appropriate fields, the user can search for a term. In this case, ‘cancer treatment’ was the search term in which the database matches it for where this appears throughout all the programmes and had turned out a table of matches in Figure 4.

The IMU experience:
To manage the different categories of users, the decision taken by the developer was to segregate users to the following categories:

- Admin users - super user rights; able to add, delete, edit records and database tables and the entity relationship diagram of the database,
- Curricula manager users - these users have editing rights and are able to add, delete and edit records in the database,
**Table 3. Example of curricula mapping results obtained with analytics**

| Using Data from          | Search Through/For          | Analytics applied                                                                 | Example                                                                 |
|--------------------------|-----------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| 1 Programme/ Semester/ Module | Learning Activities          | Sort the data into delivery types encompassing soft skills, cognitive, affective and psychomotor domains | Searching for where ophthalmology is taught in Medicine and how the various domains are used to achieve the outcomes. |
| 2 Outcome domains        | Undergraduate programmes     | Identifying which programmes or modules covers entrepreneurship as a subject       | Searching for where “Entrepreneurship” is delivered for any programme in the university and if interprofessional learning activities are possible. |
| 3 Programme/ Semester/ Module | Accreditation requirements in soft skills domains | Sorting the delivery by module, semester or delivery type | Searching through the Nursing programme to identify where “thinking outside the box” takes place in the programme |
| 4 Assessment blueprint   | Tools used for summative assessment | Sort the data into programmes, modules or semesters which then can identify support of reflective writing for the students and staff | Searching for reflection as a summative assessment in the curriculum and identifying where teaching and learning resources are needed to support both staff and students. |
| 5 Support material and references recommended for student use | Usage by different programmes | Analysis of the resources used can help the chief librarian to manage the inventories. | Searching for textbooks by a certain author or title and if it is used in any programme. |
| 6 Programme outcomes     | Mapping various outcomes from different programmes to the accreditation body outcome domains | Analysis of the delivery at particular time points | Identification of potential of inter-professional learning across different cohorts to achieve similar outcomes. |

- Non-editing users - these users are the bulk of the users and comprise of students and faculty. They have no editing rights, and have access to the entire curricula, with viewing and searching rights only.

The curricula database was introduced to both students and faculty and both parties had provided feedback to the development of the database. Both groups are provided training on how to use the database and generally both groups need to understand how to use the database to search through the curriculum and how they can apply the sort and analytics functions for the data they obtained through the search activity. Another sub-group of curriculum manager (also known as programme directors), have the duty and responsibility to update the database whenever approved modifications are authorised by Senate. These group of programme directors are allowed editing rights, whereas other users have only viewing rights and will not be able to change anything on the database.

The database undergoes a backup process every day and built into the structure of the database is who had accessed, made changes and when the changes were made. This built in log file assists in monitoring and accountability for any changes that are expressed in the curriculum database.

Training is provided for all staff and students on how to use the database. Additionally, the database has a built-in Frequently Asked Questions section where any user can refer and learn how to use the database.

*The challenges faced:*

(1) Structure of the database: The structure of the database is an important decision as the wrong structure will result in the inability for the database to search, analyse and generate reports and graphical analysis. It is recommended that in
developing the database structure and the entity relationship diagram (ERD), that personnel who are fluent in developing database structures are involved and are included in part of the team.

(2) Faculty and staff buy-in: A curriculum map is a living document and will need to be updated on a periodic basis to reflect the currency of the curriculum. These are challenges for faculty and the curriculum administrator. One solution to solve this issue is to provide Word/Excel templates with the curriculum details so as to aid the automatic import of the information into the database. Currency of the curriculum data can be tracked by four fields in the database which identifies the person who enters the data, the person who modifies the data, was modified. This information is supported with a log file which contains the history of changes.

(3) Standardised terminology and nomenclature: This is an important issue to consider, especially when multiple programmes from different disciplines are using the curriculum database. A common example is the use of the term lecture and plenary interchangeably. To resolve this issue, an extensive frequently asked questions (FAQ) section on the database includes the list of terminology accepted and used in the database.

**Lessons Learnt**

The process of developing a bespoke curriculum map using a database is an involved, iterative, and consultative process. The process of mapping should be started with a single programme, preferably one with many common educational elements across the university. One alternatively can construct the database one each for individual programmes, however, such a decision does not exploit the capabilities of the curriculum database to map through the entire curricula.

Other considerations are the accessibility and security access for users. Depending on the security and privacy level of the university and policies, the access to the database may be limited to users accessing it from specific IP addresses (campus limited). The curricula map data generally belongs to the university and there must be security processes for those accessing it. Privileges for those who are viewing the data must be different from those who are updating or involved in data entry to distinguish between the two tasks and to prevent accidental deletion and modification. There should be a built-in log file to track what are the changes made and the individuals who have made the changes it. Another important matter is how the curriculum map would look for the user on the computer and on mobile devices. The screen real estate for these devices are different and the application should dynamically recognise the access of such devices and display appropriate information on demand. Finally, the curricula database project should be self-sustaining, that is if the programmer/developer is no longer available, the database can be run with minimal human intervention.

**Moving Forward**

Curriculum mapping database with built-in analytics is an important tool to assist with curriculum management, resource tracking, and curriculum review processes. Ultimately, curriculum mapping is used to assist teaching and learning as well as preparation of learning plans by the students. Integration between the database with the learning management system (LMS) can enable the learners to be responsible for their own learning plans. For curriculum and university administrators, the database can be modified to provide a dashboard to provide a macro view of the curriculum for resource planning and administration.

Furthermore, integration of artificial intelligence (AI) to track student usage of the database can provide insight into the user engagement which can but help improve the outcomes on how the map can be used to improve outcomes.

**Conclusion**

The curricula database is useful and powerful tool in mapping, tracking and identifying curricula data and events. This becomes even more powerful with the addition of analytics, which enables the sorting of the queries.

**Take Home Messages**

- Planning the Curriculum Database Structure
- Database Application Development
- Development of the Application
- Database Mining and Graphical Output
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Declarations
The author has declared that there are no conflicts of interest.

Ethics Statement
This research did not require Ethics Board approval because it did not involve human or animal subjects.

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All figures, source: the author (Yew-Beng Kang).

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P Ravi Shankar
American International Medical University

This review has been migrated. The reviewer awarded 4 stars out of 5

I had enjoyed reading the original version of this paper and the revised version submitted by the authors. I mainly got interested in a curriculum database through a series of interaction with accreditators and accrediting agencies in the Caribbean. Most medical programs have a set of defined outcomes and one of the questions commonly asked is where a particular outcome is addressed in the curriculum and the teaching-learning methods. There is now a number of commercially available curriculum mapping programs in North America and we had examined a number of them for possible application at a new Caribbean medical school. The International Medical University in Malaysia offers a number of educational programs in health professions at various levels opening up opportunities for interprofessional learning and collaboration. Also many of the commercially available programs are primarily focused around North American requirements and the standards of North American accrediting bodies. There is bound to be differences in emphasis and in standards in Asia so I find the authors approach to be important and interesting. This well-written manuscript details the processes involved in developing a curriculum database. I found table 3 to be very interesting as it details examples of mapping results which can be obtained using the database. One of the challenges which I have faced is the absence of an educational technologist in the team which hampers our ability to develop different educational software and programs. A curriculum mapping software integrated with the overall admissions, learning management system and academic operations system can be a powerful solution and can assist faculty, administrators and students in a variety of ways. I found some of the technical terms related to databases required a second more careful reading but my experience with a commercial curriculum mapping software has made me more aware of the capabilities of the IMU database. I congratulate the authors on their initiatives. All medical and other health system educators will find this article to be of interest. In line with developing video and other capabilities of the e-journal I am of the opinion that a brief video demonstration by the authors of the mapping system will also be of interest.
Competing Interests: No conflicts of interest were disclosed.

Barbara Jennings
Norwich Medical School

This review has been migrated. The reviewer awarded 4 stars out of 5

As with the first version of the article, I think this is a well-written resource review and a useful account of an important aspect of curriculum management. The authors have cited several key papers about course mapping and the use of analytics that will be of interest to anyone responsible for the design, development, and quality assurance of curricula. The open peer reviews linked to both versions of this article also make interesting reading – because the reviewer comments and questions demonstrate the challenges faced by academic teams in curriculum management. In the IMU-Experience section of the Methods, the authors compare and contrast the use of spreadsheets and databases for curriculum mapping and clearly justify the use of a relational database. I appreciated the clear explanations of generic principles of project management for curriculum design, coupled with the specific considerations for the authors' project. Thank you for explaining the Integration options for other systems and the ability to import and export data. The take home messages section is a bit brief; more of a list of headings—perhaps the authors could have elaborated on each, as a brief summary of guidelines that readers could consider? Nevertheless, I think there are important messages in this article for course conveners in particular.

Competing Interests: No conflicts of interest were disclosed.
SRM Medical College, SRM University

This review has been migrated. The reviewer awarded 4 stars out of 5

Thanks to the editorial team for inviting me to review this paper. This interesting paper reports on the implementation of a university-wide curricula database which includes multiple undergraduate and postgraduate programmes (medicine, dentistry, pharmacy) after considering the needs of everyone who will have access to the database. The authors have clearly outlined the steps to design the curricula database, the development of the framework of the database and the analytics, challenges in implementation, the results that can be obtained from such a database and the lessons learnt with appropriate tables and figures. The authors also included specific sections on their institutional experience which expands the decisions, options and key ground rules set to develop the database. They've also highlighted many unique features of their tool, the challenges faced and the ways of moving forward. The authors conclude by stating that the curricula database is useful and powerful tool which becomes even more powerful with the addition of analytics, which enables the sorting of the queries. Curriculum mapping database with built-in analytics tool will definitely help in assisting with curriculum management, resource tracking, and curriculum review processes. So this article will be helpful to all the medical educators and administrators who are involved in designing, developing, planning, managing and evaluating the curriculum.

*Competing Interests:* No conflicts of interest were disclosed.

**Reviewer Report 23 August 2019**

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Mohamed Al-Eraky
University of Dammam

This review has been migrated. The reviewer awarded 2 stars out of 5

Thank you for your interesting paper that explains the methods used to develop your database for course mapping. You may need to elaborate more on how did you make the constructive alignment. To me, Table 1 was informative, but not detailed enough. Teaching activities should not only indicate the method or strategies (e.g. small/large group or teacher/student-centered), but you need to provide a full description on the activity, including: the task, how students are expected to perform it, time allocated, mode of submission, and how teachers would assess their performance with respect to specific learning outcome. Also, I see the language of the paper is more suitable for technical IT readers, as demonstrated
in Table 2 and almost all figures. While the paper is expected to address mainly the educational aspects and features of the database that would be of more interest to teachers, educational leaders, curriculum committee members and even students. I am sure that your product is innovative, yet it could have been presented with an educational perspective to suit medical education readership in MedEdPublish. Good luck.

*Competing Interests:* No conflicts of interest were disclosed.

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**Version 1**

Reviewer Report 24 March 2019

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**Gominda Ponnamperuma**

Faculty of Medicine, University of Colombo

This review has been migrated. The reviewer awarded 4 stars out of 5

This should be a very useful paper for anyone who wishes to map a health sciences curriculum electronically. This is something which is very difficult to explain in a paper such as this. However, to the credit of the authors, they have made a commendable effort. I would like to know more about the different options that were available to the authors at the different stages of the development of this database, and the pros and cons of selecting a given option over the others. Such a discussion, particularly with regard to the layout and the functionalities (the function buttons), would definitely assist any prospective developer of a similar database.

*Competing Interests:* No conflicts of interest were disclosed.

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Barbara Jennings  
Norwich Medical School  

This review has been migrated. The reviewer awarded 3 stars out of 5  

I think this is an interesting and well-written paper about an important aspect of curriculum management. It will be of interest to anyone responsible for the design, development, and quality assurance of curricula. Keeping track of learning objectives; documenting the intersection and integration of learning objectives; and being clear about their purpose in the education of a competent graduate are key concerns for all teachers and course conveners. But designing systems to facilitate that tends to rest with data managers within departments, or at an institutional level. This is a well-written resource review. I appreciate this type of article for allowing departments to share good practice and exchange ideas and experiences of course management. The bibliography will be helpful to readers who need to review the literature about mapping and course analytics. However, the software and system described here was driven by the quality management needs of a specific higher education institution, which probably limits the generalisability of this paper. I noted the sage advice about the importance of creating logical and intuitive systems. It is indeed important for an organisation to develop tools and infrastructure that do not require extensive historical knowledge to operate. I would like to know about any feedback that the authors have had from other faculty members since the implementation of the new database & analytics system? I also wondered about whether additional external software could be integrated with the database? For example, if there is a valuable new formative exam bank that students could use to support their learning – could it be linked to this database in a logical way?  

Competing Interests: No conflicts of interest were disclosed.

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Ken Masters  
Sultan Qaboos University  

This review has been migrated. The reviewer awarded 2 stars out of 5  

A useful description of the process involved in developing a curriculum map, and, without going into too much technical jargon, the authors have been able to explain technicalities involved. An important issue not mentioned in the article, however, is the impact of changes to the curriculum. The article does refer briefly to updating, and log records, but then does not explain what happens to the old data. This is
crucial when faculty and students come to actually using the map: • For Faculty: In 2019, I teach a course in 3rd year that relies on Anatomical knowledge, and I want to know what these students were taught in their years before. If I look at the curriculum map, I can see what is being taught to first year students and second year students in 2019. That is useful, but does not serve my purposes, because I know there were changes some time last year. I need to know what this cohort of students was taught in 2nd year in 2018, and what they were taught in 1st year in 2017. Also, I have three students who repeated courses in their 2nd year, one of whom had a leave of absence for one year, and five students who repeated courses in their 1st year, so I also need to know what those students were taught when they were in those years. Can I find this information in the map? • For Students: similarly, students in their 3rd year want to check back to see what they were taught when they were in 1st and 2nd year, not what is being taught in 1st and 2nd year now. Can they do this, and get access to those materials? Without this, the map is useful for administrators and the institution for administrative and accreditation purposes, but the benefit to Faculty and Students is marginal. If the curriculum map can accommodate these (or some of these), it would be useful if the authors could describe this, and how it does this (including a screenshot or two). If it is not able, then the authors should describe it as a limitation (that the map gives current information only, and has no “memory” of past classes and materials; it may be “living”, but it is a static snap shot of the “now”), why it was not built into the system, who decided against it, and also give some idea of whether this is being worked on for future developments of the map. Small issues: • The information under the sub-heading “Database Application Development” tends to repeat what is in Figure 2. I think it is enough to refer simply to the steps in Figure 2 without repeating the information. • Figure 2 should more correctly be labelled Table 1, and the current Table 1 should be Table 2. • “are built-into the” should be “are built into the” (and a few other language errors should also be addressed). • This sentence appears to have errors and needs to be corrected: “Currency of the curriculum data can be tracked by four fields in the database which identifies the person who enters the data, the person who modifies the data, was modified.”

Competing Interests: No conflicts of interest were disclosed.

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P Ravi Shankar
American International Medical University

This review has been migrated. The reviewer awarded 4 stars out of 5

The authors in their interesting manuscript describe the development of a bespoke curriculum
management system at the International Medical University in Malaysia. A brief description of how the system was developed and how it is being used is provided. I would be interested in knowing about factors to consider at a technical level while developing the system. Does this require a detailed knowledge of database management and programming? At our medical school we are considering using a commercial curriculum management system (CMS). The authors also mention that the CMS should be linked to the student management and the learning management system. What systems do they use for these purposes at IMU? Figure 2 will be of interest to the readers. It will be helpful if the authors can describe the issues mentioned in this table in greater detail. With regard to figure 3 the lesson outcomes have not been properly written using the standard terminology used for learning outcomes. There are a few language errors at a few places which can be corrected. The paper would be of interest to all medical educators especially considering the fact that CMS is becoming an important component of curricular management and review.

**Competing Interests:** No conflicts of interest were disclosed.