AMEE GUIDE

AMEE Guide No. 21: Curriculum mapping: a tool for transparent and authentic teaching and learning

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SUMMARY *The curriculum is a sophisticated blend of educational strategies, course content, learning outcomes, educational experiences, assessment, the educational environment and the individual students' learning style, personal timetable and programme of work. Curriculum mapping can help both staff and students by displaying these key elements of the curriculum, and the relationships between them. Students can identify what, when, where and how they can learn. Staff can be clear about their role in the big picture. The scope and sequence of student learning is made explicit, links with assessment are clarified and curriculum planning becomes more effective and efficient. In this way the curriculum is more transparent to all the stakeholders including the teachers, the students, the curriculum developer, the manager, the public and the researcher. The windows through which the curriculum map can be explored may include: (1) the expected learning outcomes; (2) curriculum content or areas of expertise covered; (3) student assessment; (4) learning opportunities; (5) learning location; (6) learning resources; (7) timetable; (8) staff; (9) curriculum management; (10) students. Nine steps are described in the development of a curriculum map and practical suggestions are made as to how curriculum maps can be introduced in practice to the benefit of all concerned. The key to a really effective integrated curriculum is to get teachers to exchange information about what is being taught and to coordinate this so that it reflects the overall goals of the school. This can be achieved through curriculum mapping, which has become an essential tool for the implementation and development of a curriculum. Faced with curricula which are becoming more centralized and less departmentally based, and with curricula including both core and optional elements, the teacher may find that the curriculum map is the glue which holds the curriculum together.*

The introduction of curriculum mapping

In medical education, much attention has been paid to curriculum development (Harden, 1986). Emphasis has been placed on educational strategies such as student-centred learning, problem-based learning, integrated teaching and community-based teaching (Harden *et al.*, 1984). The use of new learning technologies and new approaches to assessment have also attracted interest (Harden, 2000a). Changes have been made too in the content areas to be studied and new subjects have been added to the educational programme with less emphasis placed on some traditional areas of study (General Medical Council, 1993).

In contrast, an aspect of curriculum development which has been relatively neglected is communication about the curriculum. How do teachers and students know what is covered in the curriculum and where it is addressed? How do students know what learning opportunities are available to assist them to master each of the expected learning outcomes? How does assessment relate to the teaching programme? What resources are needed to mount each part of the programme? Curriculum mapping helps to provide answers to these and other related questions. Curriculum mapping is concerned with what is taught (the content, the areas of expertise addressed, and the learning outcomes), how it is taught (the learning resources, the learning opportunities), when it is taught (the timetable, the curriculum sequence) and the measures used to determine whether the student has achieved the expected learning outcomes (assessment).

As suggested by English (1984, p. 50), when he introduced the concept of curriculum mapping, 'The real genius of mapping is to give a broad picture of the taught curriculum'. Curriculum mapping provides curriculum developers, teachers, students and managers with a handle on the curriculum that they may not have had. It is a powerful tool for managing the curriculum. This guide illustrates how curriculum maps achieve this by making the curriculum more transparent and by linking the different aspects of the curriculum: learning outcomes to learning opportunities, different learning outcomes to each other, assessment to teaching and so on.

Curriculum mapping is about representing spatially the different components of the curriculum so that the whole picture and the relationships and connections between the parts of the map are easily seen. A curriculum is a programme of study where the whole is greater than the sum of the individual parts (Harden *et al.*, 1997). The curriculum map supports this through assembling the different pieces of the curriculum jigsaw together. This complete picture is more meaningful to the teacher, the student or the manager than the picture presented by the random collection of pieces which is often what they have.

The guide explains why curriculum mapping is an important tool in education, facilitating, as it does, many of

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the trends such as integrated teaching (Harden, 2000b), outcome-based education (Harden *et al.*, 1999a), the core curriculum (Harden, 1995) and multi-professional education (Harden *et al.*, 1998b). The guide explains the concept of curriculum mapping and suggests how, if used properly, curriculum mapping can lead to more effective and efficient education. It builds on previous work on the subject including that of English (1984) on curriculum mapping, Novak & Gowin (1984) on concept mapping and Du Bois & Kiewra (1989) on matrix representation systems. The guide suggests how medical teachers can use curriculum mapping to improve their own teaching. It has to be recognized, however, that experience of curriculum mapping in education is limited. It is hoped that readers of this guide find that the suggestions and information it contains will give them an understanding of the subject, encourage them to explore the technique and assist them to formulate an approach appropriate to their own setting.

Why a curriculum map?

Before we consider the concept of curriculum mapping in more detail, we shall look at why the technique has been introduced and how it can assist the medical teacher.

Curriculum maps, like road maps, serve two key functions.

(1) The curriculum map makes the curriculum *more transparent* to all the stakeholders: the teacher, the student, the curriculum developers, the manager, the profession and the public.
(2) The curriculum map demonstrates the *links* between the different elements of the curriculum, e.g. between learning outcomes and learning opportunities and between the parts within one element, e.g. between different learning outcomes.

A more transparent curriculum

Road maps of the UK highlight major towns and indicate their relation one to another, as shown in Figure 1. Such maps are useful in the planning of an itinerary for visitors who intend to spend some time in the country. The visitors can decide which towns they will visit, those to which they will make only a brief excursion and those which they will explore in more depth on this or a future occasion. Special features, such as gardens, castles or other sites of historical interest marked on the map may assist them to plan their visit; similarly, the routes of transport—the roads, railways and airports. Using such maps, travellers can plan their own itinerary, or agents or tour guides can assist the visitors to do so, recommending towns and other sites to be included in the itinerary and the most appropriate forms of transport.

In the same way, curriculum maps make transparent the area of study and what is expected of the student during the course, in terms of the areas to be mastered as prescribed in the curriculum. The map makes explicit the essential core areas to be covered and how students can achieve this.

The curriculum map, by making explicit what it is that the students should learn, offers a number of obvious advantages. English (1978) described the 'fictional

Figure 1. A map of the UK shows major towns and their relation one to another.

curriculum'. This is the declared curriculum—what it is assumed the student is learning. This may differ from the 'real' or taught curriculum—that is, the curriculum as it is delivered to the student (Figure 2). It may also be different from the 'tested' curriculum—what students actually learn. The curriculum map makes explicit the implicit curriculum and helps to ensure that what is assessed is in line with the declared curriculum.

The curriculum map, by making what is covered explicit, helps the curriculum developer and teacher to ensure that there are no gaps in the curriculum and that the

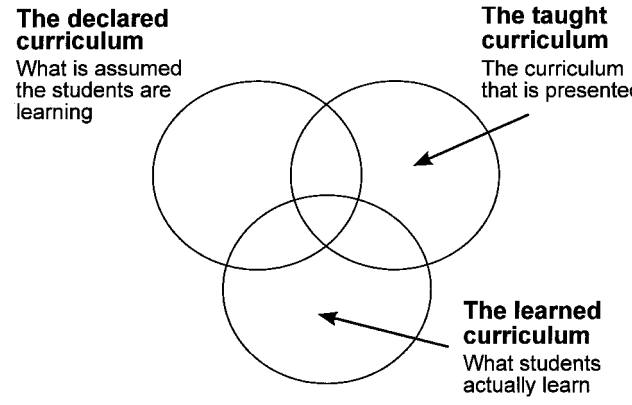

Figure 2. The declared curriculum, the taught curriculum and the learned curriculum may differ.

same area is not unwittingly visited twice with unnecessary repetition. Students and teachers can use the map to discuss which areas should be visited as part of the students' programme of studies and also the depth to which each area should be explored at the different stages of the curriculum.

Relationships and links in the curriculum

The user of a road map can see how near or far apart towns are situated from each other and whether they are connected directly by road or whether water, hills or other obstacles intervene. Travellers can look at the map from a specific perspective or area of special interest. If they are interested in sites of historic interest, they will wish to find out how such sites are related to the towns, to the road systems, railways and airports.

The curriculum map, like a road map, shows the different aspects of the curriculum and the relationships and the nature of the connections between them. With the curriculum map the user can look at how the different content areas relate to each other and how the course content relates to the learning opportunities available, the learning outcomes, and the assessment.

The expected learning outcomes for the curriculum may include an understanding of the pathogenesis of disease, skills in practical procedures and acquisition of appropriate attitudes. In the curriculum map, how the different learning outcomes are related to each other is made explicit, e.g. acquisition of appropriate attitudes may be related to the management of patients. The curriculum map encourages a holistic approach to medical care by demonstrating the relationships and links between different learning outcomes—appropriate attitudes as well as technical proficiency, health promotion as well as disease management, and communication skills as well as skills in physical examination. The map also encourages the application of theory to practice by relating an understanding of basic medical sciences to the mastery of clinical skills, thus emphasizing the relationship between 'knowing' and 'doing'.

In outcome-based education, the importance of relating the different learning outcomes is made explicit in the three-circle model (Harden *et al.*, 1999b). Wager (1976, p. 4) used curriculum maps to examine the functional relationships between the different learning outcomes: 'Diagramming these relationships (between objectives from different domains) provides a visual analytic tool for the teacher in instructional sequencing and makes evident the need for instructional strategy decisions based upon the functions being served by the performance objectives.' Concept mapping can serve as a blueprint for developing curricular goals and learning objectives, suggested Weiss & Levison (2000) and 'might be used to transform medical education by making it more integrated and interdisciplinary'.

The introduction of integrated teaching has been widely advocated (Harden, 2000b). By demonstrating the relationship between the different elements of the course content, the curriculum map offers powerful support for this strategy. The curriculum map illustrates how the curriculum may be focused round different themes including the body systems or topics such as chest pain.

The curriculum map makes possible a level of familiarity with the curriculum, on the part of both students and teachers, which is important for the successful implementation of an integrated approach. In the traditional curriculum, teachers are used to looking at the curriculum from the perspective of their own discipline or content area. In an integrated curriculum, teachers are faced with new boundaries. 'The problem our faculty faces', suggests Edmondson (1993, p. 1), 'is how to reconceptualise the subject matter in a way that eliminates redundancy, creates a smooth transition between courses, and demonstrates the conceptual interrelationships the faculty hope students will develop as a result of integrated, meaningful learning'. She described mapping as a useful tool for the development of an integrated curriculum and how a map can be used to ensure coherence across the integrated curriculum.

The different windows of the curriculum map

In the previous section, a curriculum map is likened to a road map with the main towns and how they are related and linked to each other identified. In the same way, a curriculum map can be viewed as a diagrammatic representation of the curriculum displaying the different elements of the curriculum and the interrelationships between these different elements. These may include the learning outcomes, the course content, the learning experiences, the learning resources and the staff. The map can also include the students' programme of study, i.e. how they interact with the learning opportunities in different phases of the education programme.

This section of the guide describes the points or nodes identified in a curriculum map and the categories into which these can be grouped—the 'windows' into the curriculum. It also looks at how the nodes within one window or in different windows are linked.

The windows and nodes in a curriculum map

Four key areas covered in a curriculum map are illustrated in Figure 3. In this representation, the learning opportunities are placed at the centre. These may be a single or course of lecture(s), a session in the community or an experience in a clinical skills laboratory. Related to the learning

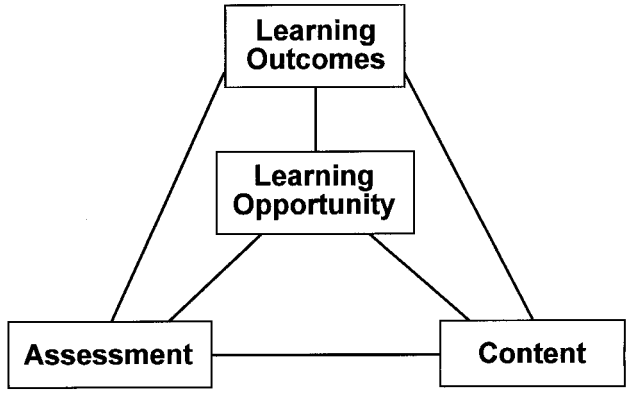

Figure 3. Four key areas of a curriculum map.

opportunities are the learning outcomes to which the learning opportunities contribute, the content or what is covered in the sessions and how the development of the students' competences to which the sessions contribute is assessed. In this way, the curriculum map provides a broad multi-dimensional overview of the curriculum and its different components. The map may be looked at from the perspective of any of these four different windows. The different windows highlight what has to be learned, how it can be learned and how the learning is to be assessed. The emphasis placed on each of the four windows characterizes different educational approaches or philosophies as shown in Table 1.

A more extensive map is illustrated in Figure 4. In this paper representation of the map, students are displayed in the centre of the map. Ten windows are shown (Table 2).

Window 1: The expected learning outcomes The expected learning outcomes that the student will achieve in the course or curriculum represent an important window in the curriculum map. The three-circle model with the 12 categories of learning outcomes (Harden *et al.*, 1999b) provides a useful framework for this window (Table 3).

Table 1. The windows in a curriculum map which characterize different educational perspectives or approaches.

Educational perspective or approach	*Window emphasized in curriculum map*
Resource-based learning	Learning opportunities
Outcome-based education	Learning outcomes
Problem-based/task-based learning	Content/areas of expertise
Community-based education	Location or venue
Mastery learning	Assessment

The sub-divisions of each of the 12 outcomes can be represented in the map. The learning outcomes are linked to other areas in the map, e.g. to the learning the opportunities—what does the learning opportunity contribute to the course learning outcomes; to the student—what learning outcomes the student has achieved, and the evidence for this included in his/her portfolio; and to assessment—the learning outcomes an assessment is designed to test.

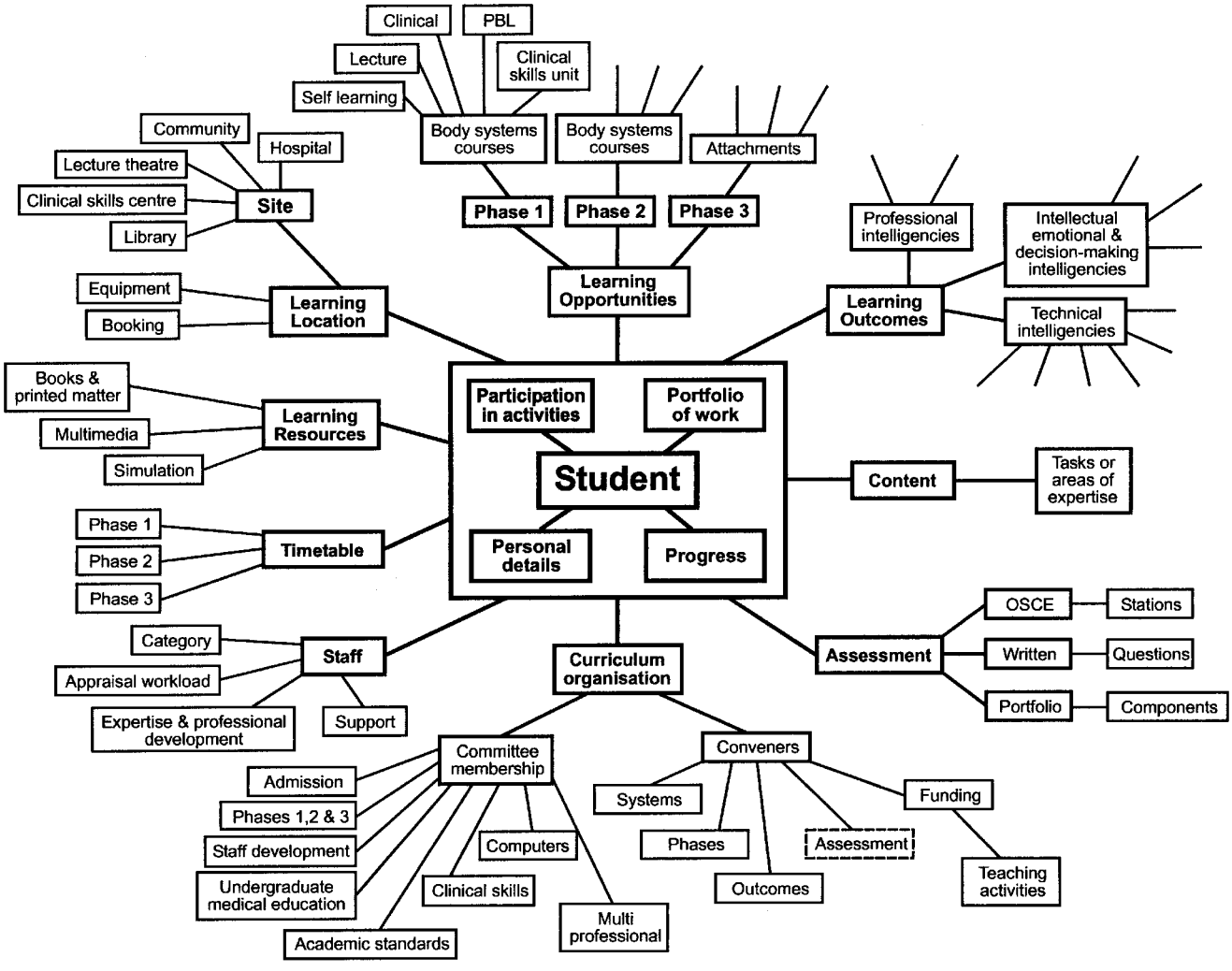

Figure 4. A more detailed overview of a curriculum map with 10 major windows identified, and examples of areas within the windows illustrated. For clarity, links between the different windows and all sub-divisions within a window are not shown.

Table 2. The curriculum map allows the curriculum to be viewed from different perspectives through 10 windows.

(1)	The expected learning outcomes
(2)	Curriculum content or areas of expertise covered
(3)	Student assessment
(4)	Learning opportunities
(5)	Learning location
(6)	Learning resources
(7)	Timetable
(8)	Staff
(9)	Curriculum management
(10)	Students

Table 3. Twelve learning outcomes.

(A)	*What a doctor is able to do—'Doing the right thing'*
(1)	Competence in clinical skills
(2)	Competence in practical procedures
(3)	Competence to investigate a patient
(4)	Competence in patient management
(5)	Competence in health promotion and disease prevention
(6)	Competence in communication
(7)	Competence in handling and retrieval of information
(B)	*How the doctor approaches his/her practice—'Doing the thing right'*
(8)	With understanding of basic and clinical sciences and underlying principles
(9)	With appropriate attitudes, ethical stance and legal responsibility
(10)	With appropriate decision making, clinical reasoning and judgement
(C)	*The doctor as a professional—'The right person doing it'*
(11)	An understanding of the doctor's role in the health service
(12)	An aptitude for personal development

Window 2: Curriculum content or areas of expertise covered Curriculum content can be defined in terms of areas of expertise to be mastered. We have described previously the use of task-based learning in planning and developing a curriculum with 100 or so tasks identified as a focus for the students' learning (Harden *et al.*, 2000). Tasks such as the management of hypertension or a patient with a seizure can be considered as areas of expertise to be mastered by the student, and these can be used as a statement of course content. 'Areas of expertise' are equivalent, in knowledge-management terms, to 'communities of practice'.

Each area of expertise is made up of a series of nodes—'units of expertise'—as illustrated in Figure 5. The area of expertise 'hypertension' includes units of expertise such as 'measurement of BP' and 'β-blockers'. These small discrete units of learning are equivalent to what has been described in e-learning as 'reusable learning objects'—small discrete units which contribute to the course learning outcomes and can be assessed. These units can be regarded as the Lego pieces or the building blocks for

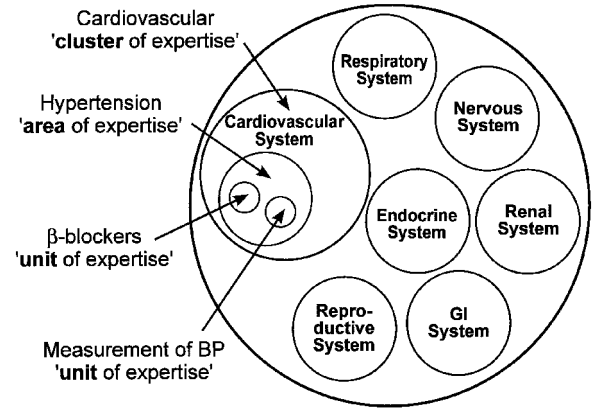

Figure 5. Content or 'expertise' window of a curriculum map. 'Clusters of expertise' are arranged round the body systems. Hypertension is shown as an example of an 'area of expertise' within the cardiovascular 'cluster of expertise'. Within this area, two units of expertise are shown: 'measurement of BP' and 'β-blocker'.

larger learning units or courses. The 'areas of expertise' can be grouped in clusters, relating to the body systems—'expertise clusters'. Hypertension is part of the 'cardiovascular system cluster' of areas of expertise.

The term 'expertise mapping' is used here to describe this area of the curriculum map in preference to the term 'concept mapping' as used by Novak & Gowin (1984). The term represents the move to a competency-based model for education and the need to include skills and attitudes as well as the cognitive domain.

Representing content in this way in a curriculum map helps to improve understanding through the provision of a structure. According to Mandler (1983, p. 4), 'meaning does not exist until some structure or organisation is achieved'. Good teachers provide such a structure as they communicate with their students about a subject. Poor teachers, in contrast, present students with what appears as apparently unconnected pieces of information. Kiewra (1997, p. 115) describes how 'structural knowledge can be represented spatially so that the interrelationships among ideas—the entire skeleton, the assembled puzzle—are apparent. Spatial representations present ideas two-dimensionally so what relates within and across topics are easily seen.' He suggests that this contrasts with standard text which presents information linearly, one idea at a time.

Du Bois & Kiewra (1989) describe the underlying structure of information as hierarchical or sequential. Descriptors such as 'types, part, components, characteristics and kinds signal a hierarchical representation', suggests Kiewra (1997, p. 119). An example of such a hierarchical representation of nodes or 'units of expertise' relating to the area of expertise 'lumps in the neck' is shown in Figure 6.

The sequential component in a map, Kiewra suggests, is represented by words such as 'steps, phases, next and before'. Nodes or units of expertise are related sequentially in the map where, for example, a pathogenesis, a prognosis or complications of a condition or treatment are described as shown in Figure 7.

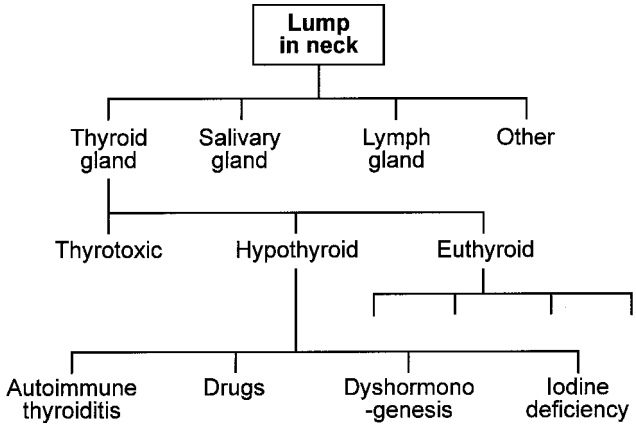

Figure 6. A section of the hierarchical element of the 'content' window of the curriculum map relating to 'a lump in the neck'.

In the 'expertise' area of the curriculum map, nodes can be represented not only hierarchically and sequentially but also as a matrix. The matrix representation system described by Du Bois & Kiewra (1989) displays structural knowledge spatially using three simple patterns: hierarchy, sequence and matrix. The matrix is the cornerstone as it develops from the hierarchy or sequencing representations. Musgrave & Cohen (1971) believe that all information has an underlying repeatable category structure and that the matrix is developed from this. In the expertise map, the repeatable category structure for the matrix is provided by the links to the learning outcomes window. Each node or unit of expertise in the map is linked to as many of the outcomes as are relevant. An example is given in Figure 8.

Another dimension to the matrix is 'the patient', as shown in Figure 7. This includes:

- age—child, adult, elderly;
- geographical, ethnic or cultural considerations;
- stage of illness, e.g. acute or chronic;
- special categories of patient, e.g. pregnant or diabetic.

Window 3: Assessment Student assessment is a key factor in curriculum development—it influences what students learn and what teachers teach. The assessment area of the curriculum map identifies the range of assessment tools used in the curriculum, and the components of each approach. It may include, for example, an MCQ paper with 100 multiple true/false items and an OSCE with 25 five-minute stations.

Assessment is linked to the other areas of the map including the learning outcomes. The map identifies the learning outcomes assessed in each of the stations in the OSCE and each of the questions in the MCQ paper. The map relates the assessment to the learning opportunities and identifies how the learning associated with the students' learning experiences is assessed. The map also identifies which staff members are responsible for the assessment, which can be useful for administrative purposes.

Window 4: Learning opportunities An important area of the map represents the learning opportunities available to the

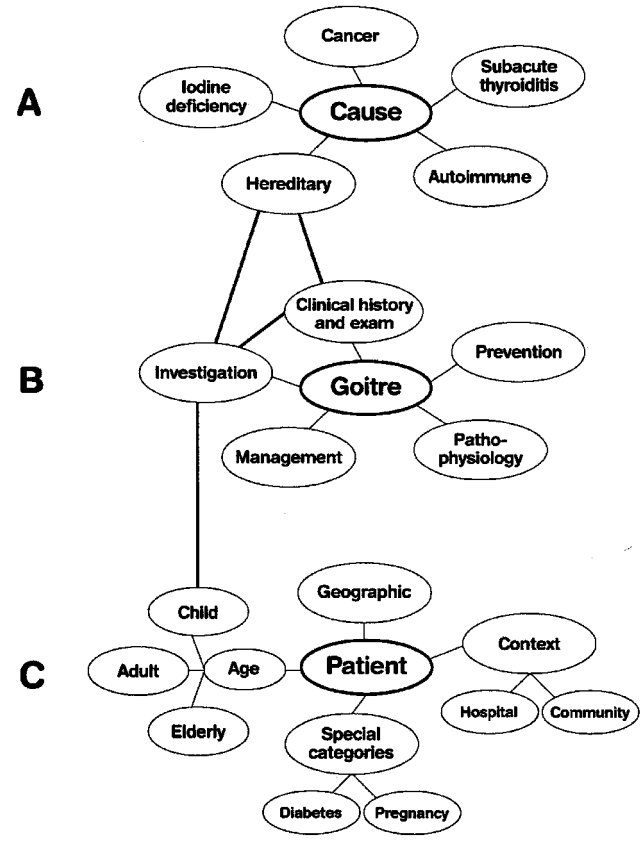

Figure 7. Three dimensions of the expertise map relating to 'goitre': (A) the causes of goitre (sequential element); (B) matrix based on the learning outcomes; (C) the patient dimension. The map links the investigation and clinical examination of a child where a hereditary cause for the goitre is suspected.

student. These can include formal presentations and whole-class teaching sessions, small-group work and individual independent learning. The learning opportunities may be classified into those available in each phase of the curriculum and in the different courses in each phase. In the example in Figure 4, it is assumed that the curriculum has three phases and that the emphasis is on system-based courses in the first two phases and on clinical attachments in phase 3.

The learning opportunities may be linked to the 'learning location' window to ensure appropriate accommodation has been booked, to 'students' to identify which students are scheduled to participate in a teaching session, and to 'learning outcomes' to identify how the learning opportunity addresses the course learning outcomes.

Window 5: Learning location An additional window shown in Figure 4, but not included in the shorter version of the curriculum map (Figure 3), is the 'learning locations'. This window includes all sites where learning may take place. Typically this includes:

- lecture theatres;
- small group rooms;
- library;
- learning resource area;

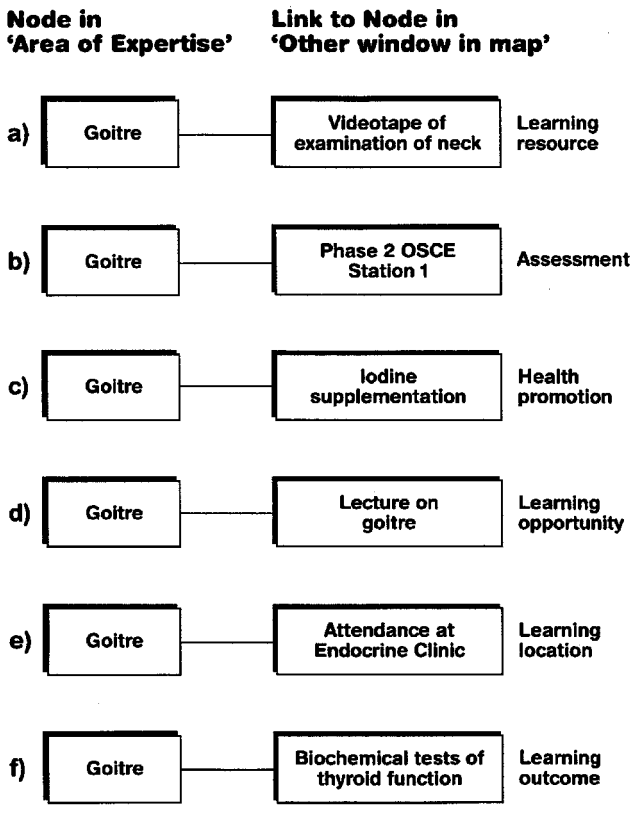

Figure 8. A curriculum map is the combined story of sets of the two nodes and their links.

- computer suite;
- hospital wards in 'teaching hospital';
- outpatient and ambulatory care areas;
- other hospitals;
- community.

Each of these can be sub-divided, e.g. named lecture theatres, different wards in the hospital and a range of sites in the community.

The 'location' window is linked to other windows, including the 'learning opportunity' window to identify scheduled sessions, and the 'timetable' window to identify their timing. The window may be linked for administration purposes to the booking arrangements for each site and to the equipment requirements at the site. This may be linked also to the 'staff' window, which includes the technical staff responsible for maintaining the equipment.

Window 6: Learning resources A catalogue can be kept of all learning resources available to support the students' learning and these are recorded in a 'learning resource' window. Such resources may include:

- books;
- articles from journals;
- computer programs;
- videotapes;
- displays;
- printed notes;
- models and simulators;
- simulated patients.

The resources may be linked to other windows including the 'learning outcomes' and 'content' windows.

Window 7: Timetable The curriculum timetable is an important and traditional view of the curriculum. A 'timetable' window shows chronologically the scheduling of the learning opportunities in each phase of the curriculum. The window can be linked to other windows including the 'students' window—the students who should participate in a scheduled teaching session, the 'staff' window—the member of staff who is responsible for the session, and the 'learning location' window—where the session is scheduled.

Window 8: Staff The staff window identifies the professional, technical and administrative staff responsible for the curriculum. It may include information about the teaching load of the members of staff, their areas of educational expertise, their appraisal and their personal development programme. The window can be linked usefully to other windows, including the 'learning opportunities', 'timetable', 'assessment' and 'curriculum responsibility' windows.

Window 9: Curriculum management A useful window to the curriculum relates to the management of the curriculum. This includes the staff who serve on the curriculum committees, the staff responsible as convenors for courses, e.g. system-based courses and the staff responsible for assessment. Information contained in this window may be used to inform teaching activity exercises and the allocation of funds that is made relating to teaching.

Window 10: Students Information recorded about students may include: personal details such as stage of study, previous level of achievement and progression through the curriculum, and participation in or attendance at scheduled learning opportunities. This area may be developed to include a portfolio of the student's work. The window can link to the other windows including links to 'assessment' (the student's progress record) to 'learning outcomes' (the student's personal learning plan) and to 'learning opportunities' and 'timetable' (the student's personal programme of work).

Strictly speaking, the inclusion of 'students', 'staff' and 'curriculum management' windows as part of the curriculum map goes beyond what one would normally expect to find in a curriculum map. They have been included, however, to demonstrate how they are closely linked in curriculum planning in practice and how a curriculum map can be considered as part of a learning management system (LMS).

Links between and within windows

Reference has been made to the two components of the curriculum map. The first is the windows and the content or nodes within a window. The second is the links between the nodes within a window and between the nodes in different windows. These relationships or links, while difficult to represent on a paper version of a curriculum map in a form that allows the nodes with their associated link to be

identified, can be displayed on a computer version of the map. It is this combination of nodes and links that is the very essence of a curriculum map. At its simplest level, a curriculum map can be viewed as the combined stories of sets of two nodes and their links. This is illustrated in Figure 8 where such links or stories are illustrated for a node—'goitre'. The links show for the unit of expertise 'goitre':

(a) the learning resource available, e.g. a videotape demonstration of how to examine the neck;
(b) the assessment of the students' competence in the area—a station in an OSCE designed to assess the students' mastery of examination of the neck;
(c) the relevance of health promotion, e.g. dietary iodide supplementation to prevent iodine deficiency goitre, one of the commonest diseases worldwide;
(d) the available learning opportunities in the curriculum, e.g. the subject of goitre and its management covered in a lecture on the topic in week three of the endocrine system course in phase 2 of the curriculum;
(e) the sites where students can acquire experience in the area, e.g. the endocrine clinic in one of the hospitals where they may get the opportunity to examine a patient with a goitre;
(f) the learning outcomes relevant to the topic 'goitre', e.g. students should know when to order biochemical tests of thyroid function as part of the investigation of a patient with goitre.

Different perspectives of the curriculum map

The curriculum map offers a number of facilities.

- It can provide a day-by-day account of student activities (the course timetable covering the organization of content and the learning opportunities available).
- It can communicate what is expected of students—(the learning outcomes).
- It can provide a clear picture of what is covered by students in each phase of the curriculum or stage of study (the course content).

It has to be emphasized, however, that a curriculum map is more than just a timetable, a list of contents, a syllabus or even a map of what is to be learned. It includes all of these and more. A curriculum map provides a multi-dimensional view of the curriculum and allows the user to look at the curriculum with different lenses or through the different windows described. The user, whether course planner, teacher or student, may look at the curriculum at one time from the perspective of the timetabling and scheduling, at another time from the perspective of learning outcomes and at another from the perspective of subjects or themes running through the curriculum.

It is not surprising that workers in the field of curriculum mapping have placed their own emphases on what they see as the key role for the curriculum map. English (1979, pp. 8–9), in his early description of curriculum mapping, emphasized the curriculum map as a record of how students' time is currently spent, and referred to the curriculum map as 'a descriptive portrait of what tasks and how much time were spent on any given set of items, concepts, skills or attitudes'. He saw the curriculum map as reflecting the 'real' curriculum and developed the concept of a curriculum map as a method of describing the status quo and the actual school curriculum as it existed. 'A map is not a lesson planned', suggested English (1979, p. 8), 'a map is task orientated, a recording of what was taught'. Other workers share this emphasis on the timetable of content in curriculum mapping but with respect to planning for the future rather that monitoring what has happened in the past. Jacobs (1997) argued the need for curriculum mapping and suggested the school calendar as the focus of the map. The calendar was used as the basis for collecting information about the curriculum plans. This proved convenient and acceptable to teachers.

An alternative emphasis is on the content area of the map. Indeed, Eisenberg (1984) has suggested that concept mapping has some of its origins in content analysis. Other writers have emphasised the links or relationships in the map. Wager (1976, p. 2) focused the curriculum map on 'diagramming the interrelationships among objectives from different domains of learning'.

Preparing a curriculum map

Assess needs

The first step in preparing a curriculum map is to investigate the potential users of the map, their needs and the questions they are likely to ask. Is the map intended for use by students, teachers, curriculum planners, examiners or administrators? Table 4 summarizes the possible needs of different user groups and gives examples of the types of questions they are likely to ask.

It is important to decide whether what is needed principally is a curriculum database emphasizing curriculum content or a learning management system which takes a broader view of how students interact with the curriculum and which tracks their progress through it.

Scope the task

The task of preparing a curriculum map may seem overwhelming. The rewards of delivering such a map, however, are high and the potential benefits are both compelling and tantalizing. A map of the curriculum is now an essential tool: every curriculum needs a map if it is to be delivered effectively and efficiently. A decision has to be taken, however, about the complexity of the map and the level of curriculum detail displayed, for example, the number of windows in the map and the amount of detail or number of nodes in each window. This decision determines the amount of work required to develop a curriculum map. In the simple version of a map, as shown in Figure 3:

- only a few windows are used;
- the learning opportunities are defined only in general terms as they relate to each of the major courses in the curriculum, omitting a detailed description of each learning opportunity;
- the outcomes are specified at the broad level of the 12 main outcomes;
- the assessment is recorded at the level of the main components of the end-of-phase examinations and

Table 4. Users of the curriculum map and their specific needs.

Users	Particular needs	Examples of questions
(1) Curriculum planners	• Overall picture of present curriculum • Working draft of future changes to the curriculum	• What learning outcomes are covered in year 1? • How does course X contribute to the learning outcomes? • What will the curriculum look like if Y is changed?
(2) Teachers	• Ease of access and simplicity of use • Ability to expand sections of map relating to their personal input • General overview of the curriculum with more details relating to the area for which they are responsible	• How does my teaching session fit into the curriculum? • What have the students learned before they start my unit? • What should they learn by the end of the unit for which I am responsible? • How is my subject or professional discipline addressed in the curriculum?
(3) Student	• Integration with study guides • A learning tool, e.g. as an advance organizer • Self-assessment	• How will a particular learning experience help me? • What is expected of me in a particular course? • Where can I get help if I have a problem?
(4) Examiner	• Identification of learning outcomes to be assessed • Basis for portfolio assessment • Security and selected limited access	• How can we be sure that the assessment reflects the curriculum? • How does this assessment relate to the assessments of the student?
(5) Administrators	• Management tool • Teaching activity data • Confidentiality	• What contribution does a department make to the curriculum? • Who is responsible for this part of the course?
(6) Accrediting body	• Provision of information at required level of detail and emphasis	• Does the curriculum meet the requirements?
(7) Potential students and public	• Simple to access • Main features presented with no jargon	• Does this programme of studies appeal to me?
(8) Educational researcher	• Detailed information in areas of interest	• What is the role of an intervention in the curriculum? • Who are the stakeholders?

details are not included relating to the individual questions or stations in an examination;

- the content is defined as a set of previously defined areas of expertise or tasks (Harden *et al.*, 2000) and a detailed specification of content relating to each area is not included;
- links between the different windows and nodes are restricted.

The curriculum map illustrated in Figure 4 is more complex with a greater *number of windows*. It includes 10 different windows with additional information noted in each window. Learning opportunities, instead of being defined at the level of courses, are defined at the level of major components of courses such as lectures, clinical experiences, and the use of textbooks or multimedia packages. Other windows are also defined in more detail.

A feature of a curriculum map is that the map and the windows in it can be presented at *different levels or depths*. Road maps may be consulted which indicate only the main towns, while others include smaller towns and villages, and still more detailed maps the layout of the streets in an individual town. In the same way, the level of detail in the windows in the curriculum map may vary. The 'outcomes' window of a map, for example, may be at the level of the 12 key learning outcomes required for a good doctor: clinical skills, practical procedures, patient management etc. (Harden *et al.*, 1999b). Alternatively, each of the 12 outcomes can be subdivided and represented in the map in more detail with their subdivisions. Assessment may be mapped also at different levels: at the level of the individual examination, the components of the examination e.g. written, OSCE or portfolio components or the questions or stations within each component. Learning opportunities can be mapped at the course level, or at the level of the learning opportunities scheduled within a course, e.g. lectures, clinical ward-based experience, computer-assisted learning etc.

Finally, a curriculum map can be *static or dynamic*. The latter is preferable with the map developed as a living structure with which the student interacts and which changes with time. In this way the map can mirror the curriculum as it evolves. Teachers may be encouraged to add to the map further information, relating to the learning opportunities for which they have responsibility. The curriculum map may be designed in such a way that it highlights the latest news or developments in a field. It

may display information about new learning resources and how they relate to the curriculum including the learning outcomes. The map may also show changes to scheduled learning opportunities including lectures. Students can plot their own progress on the map and this record, including the students' reflections on their learning, can be the basis for a student portfolio used for the purposes of assessment.

In summary, decide:

- the number and nature of the windows in the map;
- the level of detail to be included;
- the extent to which the map is static or dynamic.

Establish the links

The key links between the different windows and sections of the windows need to be developed. It has been emphasized that the essence of a curriculum map is not the nodes but the links or relations between the nodes. It is the links that provide the real power to the map. The logistics of the mapping exercise, however, means that there is a need to restrict what could otherwise be an almost infinite number of links. It is in recording and presenting the links that computers come into their own. Allen *et al*. (1993) described the impossible pattern of lines and connections that can result in presenting links on a paper version of a map. Links may be set up on a computer so that data entered in one window automatically affect other windows in the map and allow cross-checking of the data included. In constructing the links it is helpful to think of the curriculum map as a series of matrices. While the strength of a map lies in its multi-dimensionality, it may be helpful to think of the map in its preparation as a series of two-dimensional matrixes. For each specific area of content or expertise, e.g. a patient with a goitre, the learning opportunities can be described against each of the 12 learning outcomes. A second matrix may relate the 12 outcomes to the assessment instruments, including written constructed response questions, extended matching items, OSCE stations and the portfolio assessment.

Populate the windows

After the content of each window and the links have been decided, the next step is to decide

- the sources of the information necessary to populate each window;
- the person or persons who will be charged with carrying out the necessary inputting work;
- the person who will take responsibility for the process and for verifying the data.

Much of the information needed to populate a curriculum map may be contained in curriculum timetables, student study guides, lecture handouts and in statements of expected learning outcomes.

A pro forma which summarizes the required decisions about the map is given in Table 5.

Decide the format for the map

The fifth step is to decide and prepare the format for the map. Curriculum mapping was limited in the past by the problems associated with storing, manipulating and updating the large amounts of data necessary and by the inability to view easily the information from different perspectives (Eisenberg, 1984). The storage and display manually of the nodes and the links is unwieldy when the amount of information contained in the window in a curriculum map is of the order illustrated in Figure 4. The amount of detail that can be presented on paper even in one window of a map is limited (Figure 9). With the exception of the simplest maps, the use of paper-based maps is too limiting.

The ready availability and developments in computing have given the concept of curriculum mapping a new impetus. Eisenberg (1984) first piloted a computer-based system using a mainframe IBM machine. The system, however, suffered from not being readily accessible to a wide range of users and could not be modified to meet individual needs. Eisenberg went on to explore, by adapting existing microcomputer file-management software, the development of a microcomputer system as a tool for overcoming the difficulties of manual curriculum mapping. Almost all maps will now be presented in electronic form, usually on the Internet. This has a number of advantages. It allows the maps to be made available widely to students wherever they are located, whether this is in the main teaching hospital, in the community or on a peripheral hospital attachment. The presentation of the curriculum map on the Internet also allows the map to be readily updated.

Ross & Davies (1999) have described their experience in Birmingham with an electronic curriculum map driven by a series of related Filemaker Pro databases and delivered to students and staff via the web. The map consists of a matrix of three types of data—learning outcomes, taught content and key terms. The key terms, based on modified MeSH terms, provide a navigational tool working within and between the outcome and the content data.

A digital presentation of the entire medical curriculum in the Faculty of Medicine at the University of Oslo was described by Aabakken & Bach-Gansmo (2000) with dynamic links to the available electronic resources. Lee (2000) described the development, in Tufts University School of Medicine, of a computer-based curriculum database which had a tremendous impact on the students and teachers and which offered the potential of contributing through the internet to a national core curriculum and standards.

Whatever format is chosen, it is essential that the map is presented in a way that is user-friendly and meets the specific needs of the different potential users. Some users may need a broad overview of the complete curriculum map, while others want in-depth access to particular parts of the map. The underlying structure that underpins the map may be complex, but this should be simplified and presented to each user from the perspective of the user. It is important to make it easy for the user to ask a question of the map and receive in return the answer to the specific question asked. Examples of typical questions of interest to different classes of users are given in Table 4.

Table 5. Summary table of information required in the specification of a curriculum map.

Window title	Content of window	Population of window			Current status		Links with other windows	Access to window or section of window
		Source of information	Responsibility		Estimated date available	Date updated		
			Acad./ admin.	Secr.				
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
.								

Think of the past, present and future

In designing a curriculum map, it is important to decide the extent to which the map should reflect the past, the present and the future curriculum. The current curriculum map represents a snapshot of the curriculum at that point in time and describes the curriculum for each year of the students in the current academic year. Some change from the curriculum as it existed in previous years is likely. The result is that the current curriculum map, which reflects the curriculum as it exists at that point in time for each year, will not reflect the curriculum as experienced by the students during their earlier years. The first-year curriculum experienced by the current fifth-year students, for example, is likely to have been different from the first year programme as shown on the map of the current curriculum. What matters, when the

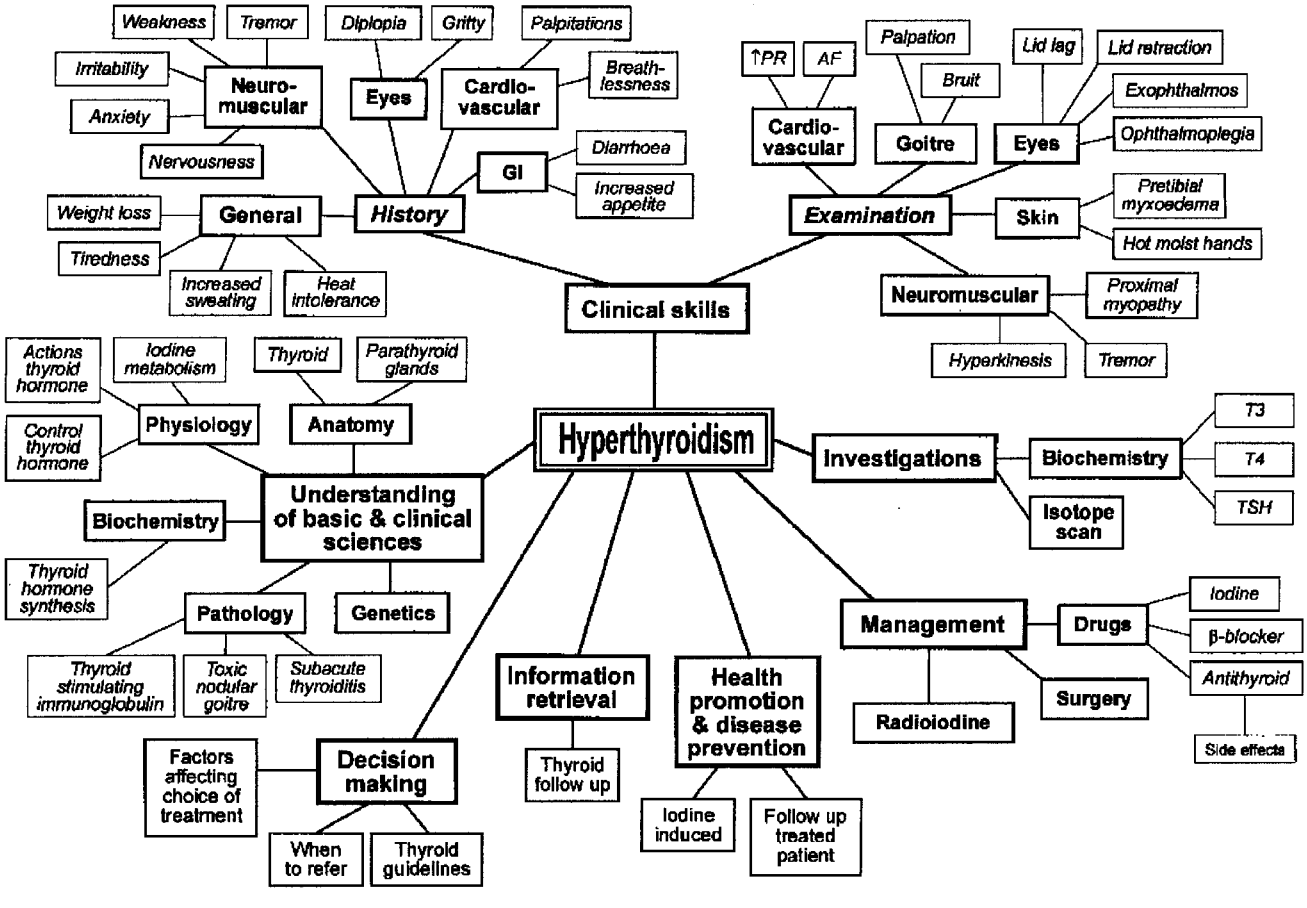

Figure 9. An incomplete section of a curriculum map in one area of expertise.

fifth year class of students is considered, is the first year curriculum which they experienced and not the programme which is now available. It is important therefore to record on the curriculum map not just the current first-year curriculum, but the first-year programmes as they existed for each of the years of medical students currently enrolled in the medical school. It follows that for a five-year course there should be 15 years not 5 years on record.

A curriculum map can also look to the future. By reflecting proposed future changes to the programme, the curriculum map can assist with curriculum planning and development. Such 'future' maps, however, must be clearly distinguished from 'present' and 'past' maps.

Decide on access to the map

A decision needs to be taken as to who has access to the map. In general, access to the map should be open to all potential users within the institution. Access to specific sections of some windows, however, may need to be restricted. This may include sections where there is detailed information about the content of the student's assessment, personal information about individual students, and staff appraisal. A decision also needs to be taken as to the extent to which the curriculum map should be made available outside the institution, e.g. on the Internet.

Familiarize staff and students with the map

It is important that the best use is made of the map and all appropriate information is captured correctly for inclusion in the map. To this end, it is essential to give teaching staff, administrators and students some ownership of the map, to provide them with the necessary background information and to familiarize them with how the map can be used. The importance of a staff development initiative relating to the curriculum map should not be under-emphasized. Maps, by their very nature, may seem impossibly complex and their use forbidding. The whole curriculum-mapping process needs to be demystified and the simplicity of access by potential users emphasized.

Plan to evaluate and update the map as necessary

It is unlikely that you will get the curriculum map right first time. It is important to plan to evaluate the use made of the map and to collect the response of staff and students to the map once it is in action.

Moreover, inevitably there will be changes in the curriculum and it is essential that arrangements should be in place to update the maps as necessary. This updating should be institutionalized as part of the accepted curriculum planning and revision process.

Allocate responsibility for the map

The production of the curriculum map will almost certainly be a team effort with the tasks of producing the specification for the map, developing appropriate computer tools and populating the map undertaken by different individuals or groups of individuals. All the major stakeholders should have input into the design and production of the map.

It is important that the use of the map is part of the teaching strategy for the institution and has the full support of teaching staff including the dean. It is advisable to allocate the overall responsibility for coordinating the work required to develop the curriculum map to one member of staff who is able to give the map the necessary time and priority.

Using a curriculum map

Curriculum maps offer a powerful tool which can be used by all stakeholders in the curriculum. The different potential users, their particular needs and examples of the questions they typically might ask are given in Table 4.

Curriculum planners

The curriculum map is an essential tool for curriculum planners or developers. It helps them to plan changes based on a full understanding of the present position, and helps them to study the possible implications of any changes made. It is particularly valuable in the context of an integrated curriculum or where one is hoping for a seamless interface between the different phases of medical education.

Curriculum mapping offers the potential of applying an artificial intelligence approach where the curriculum-mapping process itself identifies further possible changes in the curriculum.

Teachers

The curriculum map can help teachers in a number of ways. It can help the teacher to match the part of the course or teaching slot for which the teacher is responsible to the students' level of understanding and to the curriculum learning outcomes.

The map can also offer a vehicle in which teachers can provide additional information about the areas in the curriculum for which they are responsible. This may be, for example, in the form of additional information relating to a lecture, further references on a topic, or questions on a topic with associated feedback to allow the student to assess his/her own competence in the area.

The curriculum map provides the teacher with a framework on he/she they can chart the progress of students towards the exit learning outcomes. This may include an increase in the scope of the students' learning, both in depth and in breadth, an increase in the application to clinical practice and an increase in the students' proficiency.

The student

A curriculum map makes more accessible to the student the areas to be studied and the learning opportunities available. With the move to student-centred learning, the challenge, suggested O'Loughlin (1992), is 'to define a pedagogy that is truly empowering rather than one that merely gives the illusion of power'. Curriculum maps offer the potential to do just that. The maps indicate to students what, of all the

things that they might learn, are the things they must learn and identify for them the most appropriate learning opportunities available to achieve this. Lee (2000) found that at Tufts University Medical School a curriculum map could transform students' learning and make a major contribution to students' knowledge management. Edmondson (1993) has pointed out that it is paradoxical that the design of a curriculum that aims to be student centred requires extensive faculty planning and that faculty need to delineate the information that students will discover on their own. This is a role for curriculum mapping.

Just as a travel itinerary is planned and agreed by the traveller and travel agent or tour guide, so the curriculum map can be the basis for the development of a learning contract between the student and the teacher. Students can plan their trail or path through the map, helped by the signposts at the intersections. For example, if they are on the learning outcomes trail they may be led to the most appropriate learning resources or to self-assessment questions.

Examiners

The curriculum map, if used appropriately by teachers and examiners, can help to correct the mismatch that often exists between the teaching and the assessment process (see Figure 2). The map can help the examiners to construct a valid examination—one that assesses what should be assessed. The map may also be used more directly as an assessment tool. It may be used as a framework on which the students submit personal electronic portfolios. These can be used to provide the evidence that the students have achieved the expected learning outcomes.

Administrators

The curriculum map provides a valuable tool for administrators. It helps them to meet their responsibilities in administering the curriculum and provides them with a useful management aid. Using the map, they can identify who is responsible for the different teaching-related activities, and they can assess the accommodation and resource requirements. Where funds are allocated to departments or units in relation to their contributions to the teaching programme, the curriculum map can provide the necessary information that allows the teaching activity to be measured.

Accrediting bodies

The curriculum map can be a valuable resource when it comes to monitoring the curriculum and undertaking an internal or external audit. If appropriately designed, the map can be customized to meet the needs of the auditors, so that the required information is provided.

Potential students and public

The map may be used to provide for the public at large and for potential students an overview of the curriculum and a flavour of the types of learning experiences on offer.

Educational researchers

The question has to be asked as to the extent to which the use of a curriculum map is likely to help students. In the development of a new veterinary curriculum at Cornell, concept maps of the curriculum content were used for planning purposes only and were not distributed to students. The intention was to protect the students' role in constructing their own understanding of the material (Edmondson, 1993). There is little direct experimental evidence to support the value of maps in enhancing student learning. There is, however, a theoretical and conceptual underpinning for curriculum mapping including evidence that advance organizers can lead to more effective learning by the student (Ausubel, 1960). It is likely that curriculum mapping will be proved effective as a tool to enhance students' learning as investigators devise measurement procedures that are sensitive to the strengths of the approach. Curriculum mapping offers a rich area for research in medical education.

Increased attention is being paid to best evidence medical education (BEME) where decisions about teaching and learning are based on the best evidence available (Harden *et al.*, 1999c, (www.bemecollaboration.org)). A key factor in educational research is the context or situation in which the research is conducted. The curriculum map assists the educational researcher by providing this background and information about the educational context in which the intervention is being studied. The map may also help to plan how the approach or area studied can be evaluated by relating it to the expected learning outcomes. The curriculum map may itself even open up new lines of enquiry.

A possibility for the future is that the curriculum map could be developed in such a way that evidence available about educational practice and teaching effectiveness is integrated into the map. The evidence available about the effectiveness of the different learning opportunities may be linked to the learning opportunity nodes. For example, the evidence relating to the use of simulated patients to teach communication skills may be related to the link between simulation as a learning opportunity and the communications learning outcome. Analysing and relating the available evidence to all aspects of the map, however, is an ambitious undertaking and one that is beyond the capabilities of any one medical school.

Conclusion

The key to an effective curriculum is to get teachers to exchange information about what is being taught and to coordinate this so that it reflects the overall goals of the school. This has become more difficult, however, with the increasing complexity of curricula. A number of factors have contributed to this. These include increased vertical and horizontal integration, and the provision of a wide range of learning opportunities in different sites and settings including the hospital, the community, and other settings such as the clinical skills learning area, and the implementation of core curricula with options or special study modules.

Curriculum mapping can help to improve communication about the curriculum. Indeed, one could argue that curriculum mapping is an essential tool for the implementation and development of a curriculum in postgraduate as well as undergraduate education. Mapping not only assists with planning and implementation of the curriculum but importantly helps to raise the level of discussion and reflection about the curriculum and resource allocation.

If curriculum planning is to be effective, however, there are a number of requirements.

(1) The curriculum mapping initiative must have full institutional support and must be recognized as a mainstream curriculum planning and implementation activity.
(2) Sufficient time from medical, educational and computer experts must be assigned to the task of creating the map. Appropriate carrots need to be identified to encourage staff to take part in the exercise. For example, only teaching activities recorded in the map are counted in the estimate of teaching activity of individual members of staff and work on the curriculum map is itself recognized as a teaching activity which attracts credits.
(3) One member of staff should be identified who will provide the academic leadership. It is important that protected time is allocated for coordinating the curriculum mapping activities.
(4) The map must meet the needs of all stakeholders and must be user friendly. No matter how complex its underlying structure and how comprehensive the information contained in it, the map must be simple to use at the point of access by the wide range of users. It has to be recognized that users will wish to consult the map at different levels of detail.
(5) It has to be recognized that some teachers will find the map threatening because of its perceived complexity, and because of its reliance on technology. It may be seen as a threat to the staff member's autonomy with regard to his or her teaching. Why the map was introduced, the value of using the map and how to gain maximum benefit from it must be made clear to students, teaching staff and administrators. The opportunity, using the curriculum map, to take a multi-dimensional look at the curriculum using different lenses or through different windows should be emphasized as an attractive feature.
(6) The map must be flexible so that, as the need arises, it can be added to or changed in terms of what is recorded in the windows or the links. The map should be a living tool, evolving with the curriculum.
(7) The map must be able to record the past curriculum, in so far as it is relevant to the current cohorts of students, the present curriculum and the curriculum being planned for the future.
(8) An element of interactions should be incorporated into the map. Students can record their progress on the map or use it as the basis for their personal portfolios. Staff may annotate their own contributions to the curriculum.

Faced with curricula that are becoming more centralized and less departmentally based, and with core and optional elements, the teacher may find that the curriculum map is the glue that holds the curriculum together. The curriculum map can help to ensure that the best use is made of the teacher's and the student's time and to make sure that what we want to happen, happens. The map can help to ensure that the student chooses the most appropriate learning opportunities from those identified and make the best use of the opportunities chosen. At a time of financial stringency the curriculum map may facilitate the prioritizing of the use of resources including staff. Finding one's way round a strange country or town without a map may be wasteful of time and indeed the travellers may never reach their intended destination. The use of a map can prevent this. The curriculum map helps to manage the learning process by making the roles of the student and of the teacher more explicit.

The curriculum map is a method of operationalizing outcome-based education. In an age of quality assurance and academic standards, the curriculum map has a role in determining whether the curriculum meets specified standards and whether the school's curriculum is congruent with the expected learning outcomes.

Developing and implementing a curriculum map is not an easy task. However, time and effort spent developing and maintaining the curriculum map will prove to be rewarding. No good curriculum can afford to be without one.

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