The new integrated outcomes-based curriculum for dentistry was introduced at the University of Pretoria in 1997. The first participants graduated at the end of 2001. Educational principles that underpin the new innovative dental curriculum include vertical and horizontal integration, problem-oriented learning, student-centred learning, a holistic attitude to patient care and the promotion of oral health. The aim of this research project was to develop and assay a model to facilitate vertical integration of knowledge and skills thereby justifying the abovementioned action. The learning methodology proposed for the specific outcome of the Odontology module, namely the diagnosis of dental caries and the design of a primary preventive programme, included problem-solving as the driving force for the facilitation of vertical and horizontal integration, and an instructional design for the integration of the basic knowledge and clinical skills into a single learning programme. The paper describes the methodology of problem-oriented learning as applied in this study together with the detail of the programme. The consensus of those teachers who represent the basic and clinical sciences and who participate in this learning programme is that this model is practical and can assist vertical as well as horizontal integration of knowledge.

**Key words:** dental education; integrated curriculum; problem-oriented learning; vertical and horizontal integration.

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**Problem-solving: the driving force behind integration**

As stated earlier, problem-solving as a process enhances horizontal and vertical integration between the basic and clinical sciences, a deficiency characterised by the traditional discipline-based curriculum. Through the development of self-directed problem-solving, students acquire the ability to investigate unfamiliar patient problems, which they are likely to encounter in their professional careers. In this way they become life-long learners and are motivated by...
the need to solve authentic patient problems, the relevance of which becomes immediately apparent (2).

Contact sessions are based on problem-solving during which learning is facilitated while the learner is engaged in problem-solving. The session commences by first stating the problem. This is followed by a brief overview of the embedded knowledge. Students are then supplied with relevant notes on the subject to support their learning. Learning is then facilitated by the utilisation of this knowledge to solve the problem, which is consistent with the learning objective. The tutor involved in solving the problem continuously asks appropriate leading questions, which assists in guiding the learners. The learner is further required to reflect, discuss and defend the application of his or her knowledge or skills.

Differentiation is made between problem-oriented learning and problem-based learning (3). Both problem-based and problem-oriented learning will facilitate the integration of knowledge and skill. Problem-oriented learning has been defined in various ways, e.g. it is a system of instruction in which the student uses a stimulatory problem to define both the learning needs and learning objectives (4). In both problem-based and problem-oriented learning, the learner is confronted with a case study or a real patient problem to determine what he/she needs to know in order to solve the problem. A problem is defined as a puzzling phenomenon (3); it can also be seen as discovering a better way to do something. As problems are the driving force behind learning, the authors prefer to refer to this process as problem-driven learning.

Problems presented to the learning groups are related to clinical situations and are selected on the basis of scenarios, which a new graduate in contemporary oral health practice will encounter, must recognise and be able to manage. The learners encounter an application of basic biology, medical sciences and behavioural sciences as they work their way through clinical oral health problems (5).

The integrated curriculum

The first cohort of final year learners in the new integrated outcomes-based curriculum at the School of Dentistry, University of Pretoria, qualified at the end of 2001. The new curriculum was developed to facilitate vertical and horizontal integration of knowledge and skills. This was accomplished in the new Pretoria model as follows.

The ICD-DA Application of the International Classification of Diseases to Dentistry and Stomatol-
The Odontology module was selected to test and describe this concept for the accomplishment of vertical and horizontal integration.

The learning and teaching methodology to accomplish integration

This section describes the method that was followed in order to apply vertical integration in a specific outcome of Odontology, namely the diagnosis, design and implementation of a preventive programme for dental caries targeting the following outcomes:

- The diagnosis of caries
- The diagnosis of patients’ risk profiles for caries
- Design an appropriate preventive treatment plan that will include the following outcomes.

Instructing patients to be capable of exercising self-protective practices, patient motivation aimed at changing his/her behavioural pattern, creating resistant and optimally maintainable dental hard tissues, and reversing early carious lesions.

The instructional design of the integrated learning programme for the specified outcome

Integrated learning can only be accomplished if the learning programme is totally vertical integrated. The following instructional design was used to develop the learning programme.

- The natural history of dental caries.
- The biological aspects of enamel, dentine, cementum and saliva.
- The microbiological aspect of caries.
- The pathogenesis of caries.
- The natural history of dental caries in relation to its prevention.
- Health promotion measures with regard to dental caries.
- Specific protection methods with regard to dental caries.
- Caries risk assessment.
- Case studies.

Each of the above elements of the learning programme will be discussed briefly.

The natural history of dental caries

The natural history (Fig. 1) of a disease as a concept can be defined as the events that take place during the onset, progression and final outcome of the disease process without any prevention, intervention or treatment (B. Monteith, personal communication). Disease or health is a dynamic process characterised by a constant pattern of change; an everlasting battle of man (host) to maintain a positive balance amongst biological, physical, psychological and social forces.

The combination of the process in the environment (patient still healthy) and the process in man (pathogenesis and post-pathogenesis phases) may be termed, for preventive purposes, the natural history of a disease (7). It comprises all the interrelations of the agent, host and environmental forces, which create the disease stimulus leading to defect, disability, recovery or death. The three phases of the natural history of a disease namely the pre-pathogenesis (healthy phase), pathogenesis and post-pathogenesis phases correspond, respectively with the three levels of prevention namely primary, secondary (intervention) and tertiary prevention (rehabilitation) (Fig. 1).

This model is ideally suited to the integration of all the aspects of the learning outcomes of Odontology and places it in context. It explains to the student the necessity to be able to recognise healthy (biology) and abnormal tissues (pathology) for the purpose of early detection of a disease. The importance of aetiological factors and the pathogenesis of a disease in the determination of risk factors and the correct diagnosis of a disease is also highlighted. The necessity of taking aetiological factors into consideration in the planning process of the preventive programme can also be defended, in this case the need to know, understand and apply health promotion and specific protection measures with regard to dental caries. Learners will therefore be able to understand the relationship and interdependence of the discussion topics and the relevancy thereof. Learners are constantly reminded during discussion sessions of the final outcome, namely the design of a preventive programme for a specific patient. This concept is also mastered by means of a problem that is briefly explained to the learners after which they are confronted with the natural history and prevention of an African endemic disease, such as malaria, for the application of this concept.

Although learners had no formal lecture on the topic, they were required to determine, during group sessions, the aetiological factors of the disease, the disease process and the necessary preventive measures. The knowledge utilised by the student is derived from their personal experience of having visited a high-risk malaria area, the lay press and other media as well as discussions with their pharmacist on the prevention of malaria before
entering an endemic area. Utilising this model in a practical way helps the learner to understand and apply this concept in the real-world situation.

The biological aspects of enamel, dentine, cementum and saliva
The biological aspect of enamel, dentine, cementum and saliva as it relates to dental caries are discussed in detail during discussion sessions pertaining to these topics. The importance of the biological aspects of these tissues in terms of clinical application (i.e. recognition of healthy tissue) is also highlighted.

The microbiological aspect of caries
The microbiological aspect of caries such as the role of the cariogenic bacteria as the agent factor in its pathogenesis, the role of environmental factors such as diet, saliva, etc. and the importance of host factors including host resistance, forms part of this topic. The clinical application of these, namely the role of aetiological factors in the planning of a primary preventive programme, is highlighted during small group discussions.

The pathogenesis of caries
Pathogenesis is defined as ‘the preliminary interaction of potential agent, host and the environmental factors in disease production’ (7). In terms of dental caries the topic is mastered by way of small group discussions where groups must establish a definition of pathogenesis, types of carious lesions, aetiology of caries, basic structure of enamel and dentine, the process of de- and re-mineralisation and the phases of caries development. Learners are required to read a chapter in the prescribed handbook in preparation for this discussion.

The natural history of dental caries in relation to its prevention
By applying the concept of the natural history of a disease as it relates to its prevention to dental caries, the previous three learning topics, namely the biological aspects of enamel, dentine, cementum and saliva, the microbiological aspect of caries and the pathogenesis of caries, are vertically integrated into the clinical situation in a condensed form. The aim is for learners to understand the importance of the knowledge base related to the basic components and be able to recognise healthy enamel, to make a diagnosis and to determine the risk profile of a patient for caries. The same applies to the knowledge base with regard to specific protection measures, e.g. topical fluoride as well as to health promotion measures that form part of the preventive programme for a specific patient.

Health promotion measures with regard to dental caries
Health promotion involves much more than health education and is the process of enabling individuals
TABLE 1. Example of a case study and assignment

Case information

Demographic information
Female
Age 30
Married with two toddler daughters
Resident of Rustenburg in the North West Province since birth
Qualified computer software programmer
Present occupation: housewife

Dental history
Has only received a professional fluoride application once in her lifetime
Visits her dentist irregularly
No history of systemic fluoride supplement intake

Chief complaint
Gingival bleeding and swelling since falling pregnant
Complains of a clicking TM joint during mastication
Some of her teeth are sensitive to cold, sweetened foods and beverages

Other clinical findings
Plaque index of 50%
Majority of plaque present on the gingival aspects of the teeth
Stimulated salivary flow = 0.7 ml/min
Deviation of the mandible coupled with a clicking sound of the right TM joint when she opens her mouth

Medical history
3 months pregnant, expecting twin babies
Developed high blood pressure since becoming pregnant
Has a kidney problem
Complains of a high frequency of stress headaches and morning sickness

Diet
Craving for sticky sugar products such as Nougat during the last 2 months
Consumes sweetened lemon juice regularly

Clinical findings of hard tissue
16 and 46 were removed due to caries at age 10
17 and 47 inclined mesially
Extensive amalgam and gold restorations on remaining molars
12, 11, 21 and 22 are restored with porcelain jacket crowns
11 and 21 are non-vital and root filled
Gingival recessions with dentine exposure on premolar teeth
Facets are present on the incisal edges of all anterior teeth and canines
Visible demineralisation on the gingival third of the labial/buccal aspects of most teeth
Secondary caries on 26 and 36

Assignment

In terms of the above case information determine the oral health status (diagnose diseases and conditions, problems and risks), susceptibility towards caries and periodontal diseases and motivation level. Motivate and defend your decisions. Prescribe an ideal primary preventive treatment programme.

Structure your answer according to the following protocol:
1. Diagnosis of diseases and conditions
   1.1 Motivation level of the patient
   1.2 Systemic diseases that require a modification of the treatment plan
   1.3 Risk level of oral diseases
      1.3.1 Dental tissues (enamel and dentine)
      1.3.2 Periodontal tissues
2. Primary preventive treatment plan targeting the aetiological factors
   2.1 Health promotion
   2.2 Specific protection
   2.3 Therapeutic treatment

and communities to exercise increased control over the determinants of disease in an effort to improve their health (8). Three elements are involved in health promotion, namely health education, prevention and health protection. Health promotion as a topic is dealt with extensively as part of the module ‘The Community as Patient’. Elements of health promotion, namely nutrition guidance and diet planning and the application of psychological principles of patient motivation are addressed as part of the module ‘Odontology’ by way of small group discussion and simulation.

Specific protection methods with regard to dental caries
Specific protection involves measures applicable to a particular disease in order to intercept its causes before it affects man (7). When applied to dental
caries, topics such as mechanical and chemical plaque control, cariostatic mechanisms of fluoride, topical fluoride (both professional and home care products), systemic fluoride and toxicology of fluoride are addressed. Small group discussions are used to master all topics related to specific protection measures. Learners must solve problems within their groups related to each topic. Each group is presented with a case study for which relevant clinical and other information about the patient is presented to them. They are then requested to develop a treatment plan emphasising specific protection measures. Knowledge of aetiology and pathogenesis of dental caries is integrated with knowledge of preventive measures and products in solving these problems.

**Caries risk assessment**

Learners are supplied with all the indicators in order to determine a patient’s caries risk profile. This is classified as low, moderate or high. Knowledge of these factors is then applied by allowing the students the opportunity to determine the caries risk profiles of several clinical cases.

**Case studies**

In order to prepare learners for group discussions on case studies, additional information with regard to the clinical reasoning process is given. Application of this concept is reinforced in the design of a primary preventive programme for the patient. Learners are briefed with regard to group discussion techniques/theories and group dynamics. Heterogeneous groups are selected according to their learning preferences.

Well-structured clinical cases providing all relevant information with regard to the condition of the patient's oral health are available to learners with the request that they analyse the data and provide a diagnosis and risk assessment with regard to all oral diseases. Table 1 provides an example of a case study presented to students. Although this module concentrates on diseases of the hard tissues, diagnosis of diseases of the periodontium, soft tissues, tongue, temporomandibular joint, etc. are included in these exercises. The latter facilitates the integration of knowledge between the different clinical modules (horizontal integration). It is not expected of students to design a detailed primary preventive treatment plan for diseases other than those of the hard tissues. It is, however, expected of students to outline a detailed primary preventive programme for the caries problem. A tutor facilitates these discussion sessions and groups are encouraged to discover the answers within the group. Such sessions are concluded by feedback and evaluation of the diagnosis and treatment plans of the various groups.

**Conclusion**

A long-term goal of dental education has been the successful integration of basic sciences into the clinical curriculum. Such integration should make learning more relevant and ultimately more available for use in a clinical context (9). The authors are convinced that this model can be adapted to suit other modules or parts of modules within the new Pretoria curriculum.

The consensus of those teachers who represent the basic and clinical sciences and who participate in this learning programme is that this model is practical and can assist vertical as well as horizontal integration of knowledge.

**References**


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