Quality and quality indicators in education in general and applicable in prosthetics and orthotics education

ing. F.C Holtkamp M.Sc.
Fontys University of Professional education, dept. Engineering / Orthopaedic Engineering
Eindhoven, The Netherlands

1 Introductory.

1.1 The design process, introduction to the Brief.

In 1998 the Knowledge Centre Medical Engineering of the Fontys University was invited to research the possibility in developing a four-year full time Bachelor-level course in cooperation with a foreign institute, The Katholieke Hogeschool Kempen (KHKempen) in Geel Belgium. It should be noted that the KHKempen already offered a prosthetic and orthotic at the level of Higher Vocational Education since 1994. This research study has been made possible by TRIS. Trans Regionale Institutionele Samenwerking (Trans Regional Institutional Cooperation, in border regions). Fontys University in Eindhoven (the Netherlands) and the Katholieke Hogeschool Kempen in Geel are at a geographical distance of each other of 45 kilometres. (Belgium TRIS offered the financial possibility to investigate the possibilities in cooperation, between the two Universities.

The design brief therefore became very clear and concrete. *Investigate the possibilities in cooperation and if there are possibilities developed a Croho document and design the course as a whole.*
In this formulation three phases can be determined. An investigation phase or a feasibility study, a concept design described in a Croho document (central register for university studies leading to a Bachelor title), and after a formal approval, a final course design.

At first in the beginning of the feasibility study and later on during the whole design process a round table conference was organised every two months. This roundtable conference was formed by members of the profession such as Orthobanda (Nederlandse Vereniging van Orthopaedisten en Bandagisten), BBOB (Belgische Beroepsvereniging van Orthopedisten en Bandagisten), and ISPO (International Society of Prosthetics and Orthotics, dept. Netherlands and Belgium), ministry of health, assurance companies, the KHKempen and of course Fontys University. This two monthly roundtable conference has been very helpful during the whole process, on the one hand because it was a very effective communication channel thru to all the section, so people knew what was going on, on the other hand it was very helpful in putting the minds together finding all kind of solutions for problems which were faced on a regular bases, as in every design process will happen.

1.2 Feasibility study to a prosthetics and Orthotics course at Bachelor level

Why a need for a Higher Vocational Education in prosthetics and Orthotics?
Although it seems a bit strange to answer a question like this, but this question had to be answered in order to get at the very end an official approval by the government at all. In order to find this answer, research had to be done towards questions like:

- Needs for society for this type of graduates;
- Numbers of graduates are needed for the profession both in short term as well as in the long term;
- Appropriate expending government founds;
- Content frame of reference of the course;
- Institution profile.

These questions are answered in the Croho document "Hogere Beroepsopleiding Orthopedische Technologie, a necessary application document for new courses needed for the ministry of Education.

1.3 The preconditions

A number of preconditions have been mentioned already in the preceding paragraphs Summarised these are the following: finance, macro suitability, expediency, efficiency , student numbers.
Two other preconditions not mentioned before which are of great importance in succeeding the realisation of the curriculum are the following:

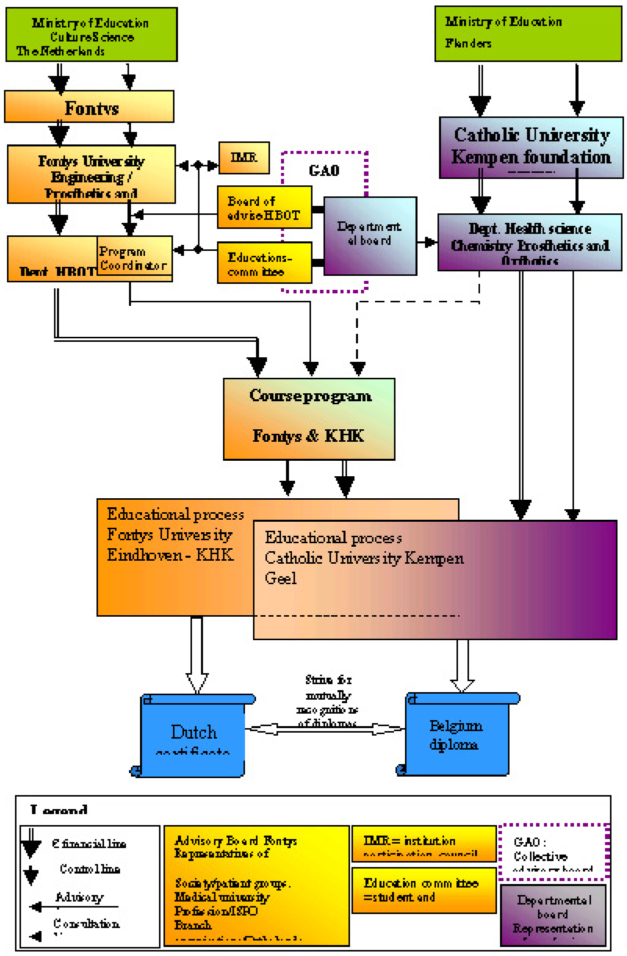
- Two countries, two school systems.
- Organizational conditions

Starting with the first. As mentioned, the curriculum will be offered in to different places, both in the Netherlands as well as in Belgium. A major difference between both Universities is the way of teaching. In Belgium, more specific at the KHKempen, a more conservative way of teaching is used in transferring knowledge from lecturers towards the students.

A second precondition is a grasp of all the things that are necessary to be able to offer a curriculum, such as the advisory board, board of examiners, examinations regulatory, student facilities such as student organs, tutoring, etc. Together with issues of diplomas or certificates of both universities and how justify this are two major issues that must be solved before cooperation is possible.

The solution towards all these problems was the design of a cooperation model in which both universities will be able to account for their own responsible parts and also will be able to cooperate together in the establishment of the common parts of the curriculum. This cooperation model or organizational model is Figure 1. This model shows clearly the connection of the two Universities with their departments of education. Also the connection of both individual Universities with all the organs round the curriculum is showed as well as the connecting parts, e.g. the GAO (Gemeenschappelijk Advies Orgaan, in eng. common advisory council). Clearly showed is the result after graduation, the Dutch certificate and the Belgium Diploma. The certificate is reserved for Dutch students and the Belgium diploma for Belgium students, both according to the national law. In the coming years however effort will be put in to harmonisation of both diploma's, i.e. one common diploma.

Concluding: A major issue has been solved introducing the organizational model as mentioned. This model shows precisely who is responsible for what part of the organisation. Also a solution for the difference in curriculum duration has been found. The differences in preliminary training and age differences have been made visible. Paragraph "Design principle" will go into the detail of the educational model, (also showed in figure 1).



The organizationmodel

Figure 1

1.4 Design principle, designing out of a form perspective

A central issue in designing the prosthetics and orthotics Bachelor curriculum though it is never made explicit is the choice of perspective from where out the design process will take place. At first sight is higher educated employees developing, in practice in a methodological way a lot of new knowledge. Acknowledged is the fact that outside universities and research centers a lot of knowledge production takes place. In this connection the common production of knowledge inside universities and laboratories is indicated as a "mode I"- knowledge practice (Gibbons, *1994*). In the "mode II"-practice it is context related knowledge production characterized among other things by trans disciplinarily, heterogeneity, and context- and application alignment. It is this growth of knowledge, which can be interpreted as a major driving force behind the design of new curricula; a lot of latent knowledge is already there. It only needs to be processed to make it available. In the curriculum design of the P&O course, this is exactly what was the case. A lot of knowledge was and is available, also new developed knowledge, that now had to be converted into the format of a four-year curriculum.

Because of the fact that a lot of knowledge, skills, facilities and regulations are known and available, the only problem was how to implement all this, in order to make a feasible, high quality curriculum that can be studied by students in two different Universities. It is these reason why the design process took place from out a form-perspective point of view. Lecturers, counselors, had to meet specific requirements. Their reputation must be in order and having "a right of speech", must be a role model, love of the profession, etc.

At Fontys University a process about quality, quality assurance and studybility (to make it possible for students to graduate in 4 years time, without delay) has been going on, aimed at the Educational paradigm "Higher Educating". A number of examples are given below:

- Interdisciplinary and multidisciplinary learning is becoming instead of knowledge transfer in a conventional way.
- Education is becoming more and more aimed at independent and self-activation activities of the students, whit competence as basic assumptions. From out these competences, objectives and final attainment levels can be formulated.
- The content of the curriculum is becoming more and more determined by the dynamic of professional profiles and rapidly changing professional demands.
- Learning is even more aimed at the professional practice.
- Higher educating demands modern study facilities connected to national and international communication networks.

These innovative changes together with the basic assumptions and the facilities offered by the partner university, combined with the fact that the curriculum is offered at two Universities justify this choice.

1.5 Concept and prototype

Taking all the above-mentioned considerations into account there is more then enough material to design the curriculum according to the Dutch law and to accommodate the profession of prosthetics and orthotics.

In concept and prototyping the educational model, the designation of graduates and curriculum content has to be taken into account.

Two questions remained:

1) How to determine the amount of hours spent on a certain subject.
2) How to deal with new insights in education, especially the matter about competences.

1.5.1 Curriculum content

The answers are of course not easy to give. Based again on experience, an idea of how many hours must be spending in order to master a certain skill is direct related to the number of laboratory hours. This is according to the personal experience of Belgium and Dutch professionals and related to the amount of means that is available. As will be mentioned in chapter 8, the amount of time spends to a diversity of educational subjects; skills and even clinical periods differ quite a bit when a number of educational institutes are compared to each other. Therefore it looks like that no unambiguous dimension for training skills and exercising subject is available. Educational-, and cultural backgrounds looks to be valid arguments for this difference.

For this curriculum in particular it means (partly) fitting into the first year engineering curriculum, combined with fitting into the Belgium curriculum. In this way an efficient use of available means is achieved.

1.5.2 Competences

What makes an Orthopaedic engineer an orthopaedic engineer? In other words what kind of (distinguishable) competences must have an orthopaedic engineer.
Besides these competences and qualifications specific competence must be defined and implemented in the orthopaedic engineering curriculum. This process started two years ago and is still in progress, in fact it is a never stopping process due to new insights and knowledge.

First of all a definition:

> *A competence is a, due to the collective learning process obtained ability which is available for the group to realise a specific common objective, (Weggeman 1997)*

Within the developments in designing of the orthopaedic engineering curriculum the group mentioned above could be seen as a compilation of orthopaedic workshops, institutions, rehabilitation centres and industry that have a need for orthopaedic engineering staff educated at university level. The common objectives that need to be realised will be

reviewed so that this professional group can formulate a realistic strategy to cope with the future. Underneath, an explanation is given how to come from out of these company objectives via general esteemed competences of the orthopaedic engineers, which will be further explored towards final attainment levels and learning objectives. By means of an example will be indicated how to go thru this process.
One of the main objectives of a business, namely; generation of profit and continuity is initially taken as a basic assumption. Generation of profit, continuity and a cost-effective process is a major rule in surviving the business, even if this business a part of the healthcare sector. From out of these business objectives, in designing lectures, lessons, laboratory sessions, these items will be further explored.

An example will follow, in analysing a number of learning objectives which has to be set up to be able to educate a orthopaedic engineer whom has the knowledge to realise the mentioned business objectives. Of importance esteemed, in order to realise continuity of the orthopaedic workshop, is to be able to be working on product development, to introduce new products. This new products needs an innovative design trajectory. Therefore students need to know how to innovate. This is seen as an essential competence. Out of this competence one can ask, which field of knowledge is a necessity for a student to master an innovation process. Examples of fields of knowledge are: Medicine, knowledge of materials, biomechanics, life science etc.
Out of these fields of knowledge, final attainment levels or, subject benchmark statements can be defined. Biomechanics is taken as an example. To come to a biomechanical design process, a student needs to be familiarized to static's, stress and strain, designing, anatomy and physiology. From these final attainment levels lessons with learning objectives can be arranged.

The above-mentioned indicates, how in the research of designing education problems and questions will be handled. This is a continue process and open for new insights and ideas.

1.5.2.1 Perception of determining competences for HBOT.
According to Weggeman, A competence is a, due to the collective learning process obtained ability, which is available for the group to realise a specific common objective. Skills and knowledge, with a causal relation to a successful realisation of desired company objectives help to determine the competences which are asked for.

Competences are a cluster of
- "Broad" skills,
- Attitude, and
- Knowledge "behind the skills".

Examples of competences

Aalysing	International
Strategic thinking	Ability to abstraction
Making plans	Vision of future
Knows the organisation	Responsibility
Leadership	Process monitoring
Communicative skills	Learn to learn
Corporate values	Research, data
Innovative thinking	Publish
Interdisciplinary work	(Self) reflecting, assessment, evaluation

Competences can be successfully introduced if the university is able to create an attractive learning and study climate. As a graduate of the higher vocational education of prosthetics and orthotics, an orthopaedic technological ingenieur is a person with perception of transformation of the material world in the field of rehabilitation and rehabilitation engineering. To meet these goals a general vision of competences of private enterprises, trade and industry must be developed.

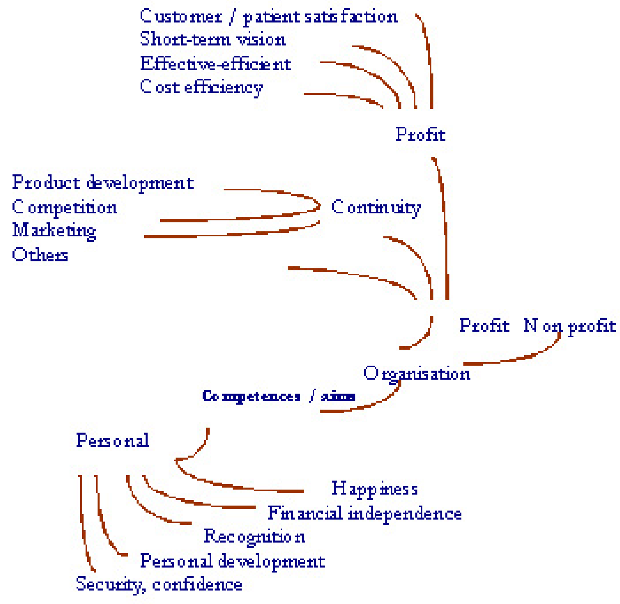
Private enterprise, trade and industry → desired results

→ Profit
→ Continuity

→ Good product
→ Short-term policy
→ Long-term policy
→ Product development
→ Marketing
→ Mission/Objectives

At this time the question can be asked, how can a university educated staff member meet all this? Therefore the University of professional education HBO competences had to be characterized:

- Knowledge of the existing organisation. (What and how to organise?)
- Knowledge of technological capability. (What can be realised?)
- Agreement of a goal. (Is there consensus?)
- Knowledge of state of the art/development / innovations. (How to get the most out of it?)
- Vision for the future (Where to go?)
- Knowledge of project realisation (How to get there?)



Competences and aims Figure 2

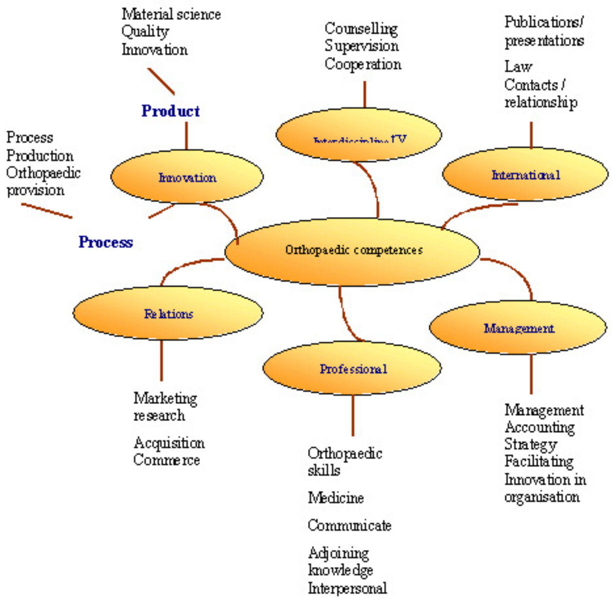
Figure 2 shows a number of parts and divisions of general elements, which forms the competences. Summarised, the general necessary competences to start as a graduate within the occupation are:

1. Is able to function in a dynamic, multidisciplinary and international environment, a variety of activities (more in broadness).
2. Is able to generate innovative ideas and is able to take initiatives, combinative and think of complex procedures.
3. Is able to maintain the skills up to date, expand and transfer.
4. Is able to weigh by virtue of the profession and ethic dilemma's, based on social accepted standards and can make a decision.
5. Is able to communicate effectively in a diversity of manors at every level.
6. Is able to work independently as well as cooperate in a multidisciplinary team in a structured way to achieve the necessary results, and if appropriate based on specific methods?
7. Is able to function effectively in a variety of conditions.
8. Is able to perform management tasks, development and execute company / institution policy
9. Is able to reflect their own behaviour and attitude, give and receive feedback.
10. Is able to contribute in an active way to the developing of the profession.

Defining general competences is not enough to describe the entire profession. Therefore also a number of specific competences has to be defined, the so-called professional competences. These professional competences are just like the general competences subject to change and fine-tuning.

1.5.2.2 Professional competences, what is specific for P&O.

Professional competences distinguish the profession of an Orthopaedic engineer with other professions and must be therefore rather specific in what is required for the profession. In Figure 3 is showed how separate requirements are linked in a way for competences. Prosthetists and Orthotists in combination with rehabilitation and mobility expertise, forms the profession of orthopaedic technological engineering, or rehabilitation engineering. A central issue in this profession is acquiring, collecting, and recording of data and



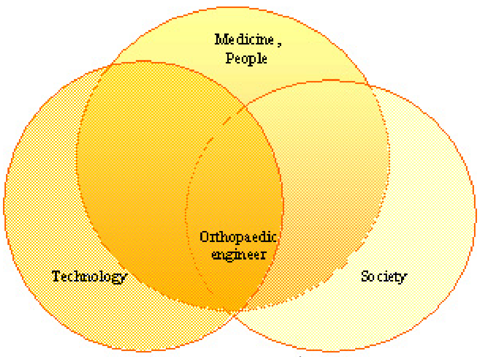
Separate requirements Figure 3

measurements, fitting, producing of supporting- or replacement parts (exo) for the human body.

Graduates of the professional education in prosthetics and orthotics will meet the competences stated below in order to perform the occurring duties as a starting professional.

1. Acting as a professional in the field of healthcare and technology with the client / patient as center, in a high developed ethical consciousness based on respect and equality, combined with an ability for empathy and care and able to see the orthopaedic profession from the users point of view.
2. Analyzing questions and problems in rehabilitation, centered around the muscular / skeletal system and define these in an intermediary role between, medicine, technology and society, with the intention to implement and produce these provisions on an orthopaedic technical basis, in order to preserve or improve quality of life and mobility.
3. Advising of clients/ patients and employers with regard to liability, and responsibility of products and working conditions and able to co-operate and communicate in order to document and quality assure the whole process. Is, from out of the design process, able to make considerations regarding,
4. Management, market, environment, quality manufacturing and maintaining in relationship to the total lifecycle of the product.
    a. Insight knowledge of anatomy, physiology and pathology, structure function and dysfunction of the human body.
    b. Insight and knowledge of possibilities to prevention and reintegration.
    c. Insight into structure and tasks of health service, law, regulations and standards.
5. Measuring and producing of orthopaedic provisions (prostheses, orthoses and bandages, rehabilitation and walking aids),
    a. Insight into biomechanics, mechanics, material science, measurement systems in combination with anatomy, physiology and pathology, structure function and dysfunction of the human body.
    b. Insight, knowledge and skills to manufacture orthopaedic provisions.
    c. Insight into all technical equipment, which is being used in an orthopaedic workshop.
6. Analyse, convert and formulate specifications (wishes) of the patient / client into functional medical and technological specifications for the benefit of the design and development of orthopaedic provisions (prostheses, orthoses, bandages rehabilitation and walking aids). Innovation plays a large role, not only in treatment and product development but also in knowledge transfer, therefore knowledge about other relevant professions both in healthcare and social sectors as well a technical is necessary.
7. Managing of a private enterprise, trade or company, institute or organization which is acting in the orthopaedic work field, document quality assure and evaluate the technical process and provisions.
    a. Guide employees in a design process to production and manufacturing of orthopaedic provisions.
    b. Coordinating labour employers and other sectors of service, necessary for the benefit of manufacturing of orthopaedic provisions.
    c. Taking care in performing to meet the directives, law and standards of the professional requirements, and the resulting responsibilities and certification of orthopaedic provisions.
    d. Taking care of an adequate financial settlement or completion of the orthopaedic provisions in relation to assurance companies and clients / patients.

A graduate needs to have next to the above mentioned competences, also the skills to anticipate in changing insights of insurers, changing law, maturity of patients, higher requirements and faster delivery periods demanded by prescribers (physicians), competitors, international developments and supply management, for the benefit of an efficient management, protocolisation of product choice and standardisation of procedures are also items which becoming more and more important. In the professional practice, the graduate is acting as the speaking person in relation towards physicians, patients and orthopaedic employers who are taking care for the manufacturing of orthopaedic provisions. It is therefore that the graduate must have the knowledge and the skills to manufacture a diversity of orthopaedic provisions.



The three main pillars.

Figure 4

Concluding: the orthopaedic engineer is a person with an attitude, qualifications, skills and motivation, for the benefit to solve quality of life questions in relation to rehabilitation and mobility, based upon three pillars or areas.

Pillars are:	People:	Involvement, (patients, clients)
		Medicine, (physicians, prescribers) Multi-disciplinarily
	Technology:	Knowledge, Skills, Techniques, and Attitude
	Society:	Law, Quality assurance, Regulations

These main factors are also visualised in figure 4.

The above defined competences, combined with the general professional competences, are the factors which distinguish the orthopaedic engineer from other professionals and makes the therefore in a way unique. These complete set of competences is the fundament to derivate the more specific final attainment levels and objectives, such as the subject benchmark statements made by the quality assurance agency for higher education (2001) for the United Kingdom.

1.5.3 Learning styles.

Having available a competence set, final attainment levels, and objectives, gives enough ingredients to arrange the programme which student can attend to. Learning styles is a central issue. A number of possibilities are available to transfer knowledge and skills. Classes and lectures as well as laboratory practice is used and a lot of experience is available. Also clinical practice is a must for students to practice and get experienced. Beside these forms of teaching also a use of problem and project based learning is introduced, just to practise a lot of skills, (professional, social, technical, attitude) based on the formulated competences. Also a portfolio for students is introduced. The students must keep a portfolio of them to a record and survey their achieved results. Both the problem based learning method as well as the portfolio which appeal a lot of the engagement in self directed learning of the student and for as far as possible, it simulates the real world and helps the student in the process of problem solving. (Dool, *2000*). This curriculum is therefore a mix of conventional learning methods and skills training and a more modern way in counselling and supporting a student in their way becoming a skilled professional, using problem based learning and portfolio.

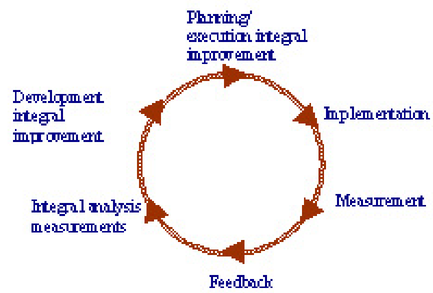
This curriculum (product) came into being during the design process in cooperation with the already earlier mentioned partners. It is however due to the educational reform and in relation with the forthcoming accreditation, interesting to know how other universities have designed their curriculum and deal with questions like, how many hours should be spend on technical subjects or for example laboratory hours and are other university also working with problem based learning methods.

1.6 Accreditation

In the near future the curriculum will be assessed by a VBI, a visitation-judging institute in commission of the VNAO. (Vlaams Netherlands accreditation organization). Six subjects are major issues, which will be assed, (Vlaams Nederlandse Accreditatie Organisatie, *2003*).

These subjects are:

- Aim of the curriculum
- Programme
- Effort of personal
- Facilities
- Internal quality assurance
- Results.



PDCA circle
(source: kwaliteitszorgsysteem bachelor opleiding β version)
Figure 5

The general and specific competences forms the fundament of the curriculum which is designed and developed and helps to specify in detail what factors of influence are important. In this way the competences are of major importance in assessing the aim of the curriculum and the programme by the VNAO.

Part IV of the mind map (appendix I): qualification and quantification, is a part which, if handled in a correct way, gives feedback to the curriculum design and offers valuable information about new developments in education. Part IV can be split into two parts related to quality evaluation. One is a form of quality evaluation directed by the government. This is a compulsory evaluation process performed by the VNAO.
The other evaluation process is an integral part of a continue design and adjustment process, showed in Figure 8 benchmarking, in Figure 6 design process and in figure 7 Design of education, Figure PDCA circle.

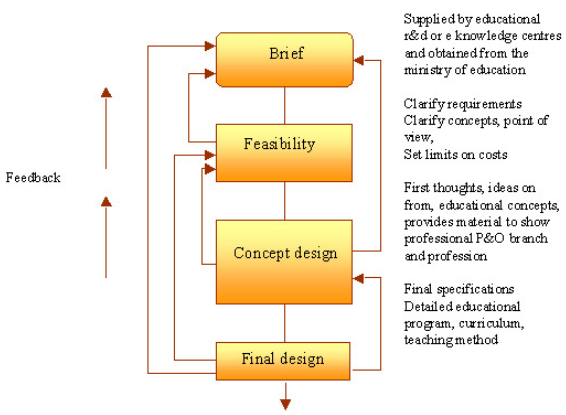


Figure 6: Design process

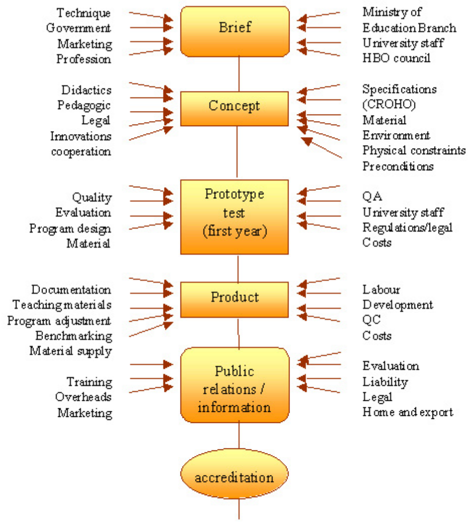


Figure 7: Designing education

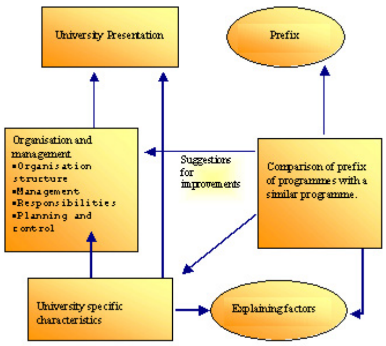


Figure 8: Benchmarking

2 Reviewing the curriculum design in a context of PDCA and EFQM quality assurance systems

2.1 The state of affairs.

This chapter reviews the designed course in a context of PDCA and EFQM quality assurance system, for as far a curriculum design can be reviewed, because in reality it is a continuous process, in relationship to the acquired data and the quality assurance systems used at Fontys University.
Although it is a common use to design courses using the experience of staff and copying ideas from those who were first, it shows also that designing and evaluating courses on the hand of design principles and "evidenced based" data, see mind map part II and III (see appendix I) to obtain a desired course is also possible.
In order to achieve this, research has been done in the field of “how to design education”, quality measurement techniques and evaluation methods.
By doing this, answers were found for questions as, what kind of subject should be or must be covered in the study. Finding answers as: what percentage of certain educational parts or specific subjects is an optimum, and what kind of learning styles are appropriate, and the discussion about the length in years of courses are more difficult to answer.
To start with the last mentioned item. Study duration is most often a legally described period. In cases of regular, initial education it is therefore three or four years, depending on political choices.
Reviewing the acquired data in order to retrieve the answers for, for instance, the optimum percentage for clinical lab activities of traineeship period of theoretical aspects of the curriculum, it is appeared to be very difficult to come up with one absolute percentage, thus a number of hours. In practice although all general expected items are covered, there is however a large variation within the allocated hours for curriculum and study parts.

2.2 The near future

For future data acquisition and evaluation also methods and techniques like desk and field research will be used. Quality assurance models like the EFQM (see figure EFQM), and by Fontys internally used quality assurance system, "voortdurend verbeteren"(Veerman, *2000*), and 'Kwaliteitszorgsysteem bacheloropleiding β-versie' (Rexwinkel, *2001*),] models will also be used for future data acquisition and evaluation. Point of departure is Philip B. Crosby's definition of quality: Quality is fulfilling requirements (Crosby, *1998*). One of the reasons for this is that the KHKempen is using the EFQM model in quality assurance and Fontys is using the PDCA cycle (figure 5), with can be seen as a derivation of the EFQM model and can be fitted in the accreditation model in the Netherlands.

To be complete, in the end stage of the design process, and in relation to quality assurance and future accreditation the two quality systems will be discussed in a broad way, because these tools will be able to generate valuable information in order to improve the designed curriculum.

2.2.1 EFQM.

The main objective of EFQM, the European Foundation for Quality Management is to help profit or non-profit organisations is realising in improving their results. The EFQM-model, which recognize a number of approaches to become an excellent organisation with an excellent product. Within this approach a number of basic assumptions can be distinguished. These assumptions forma also the basis of the EFQM-model. Mostly are these basic assumptions summarized into the term, Total Quality Management (TQM). Figure 9, EFQM is a proposed quality review process, which uses the TQM model criteria and lists questions that should be asked.

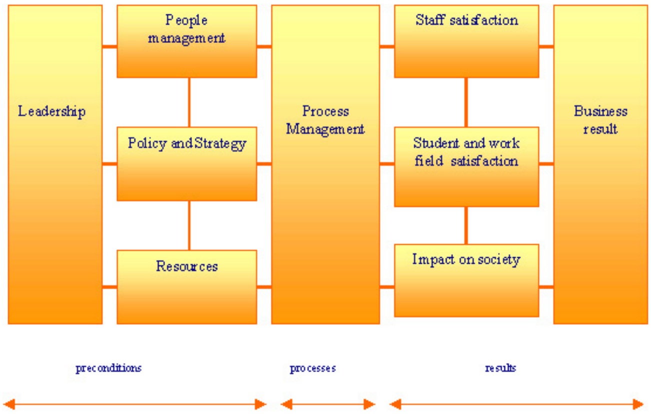


Figure 9

The Total Quality Model criteria can be described in a summarized way as follows:

1. Leadership and behaviour.
2. Strategic planning
3. Techniques and continuous improvement
4. People
5. Quality assurance, process management.
6. Quality and business results
7. Customer satisfaction
8. Community (impact on society)

Accreditation is a process of quality assessment, whit at the end a result of an approval / non-approval.

Aspect	Accreditation	EFQM-model
Objective	assessment of a university Meets the HBO – standard	Control of organisation and improvement
Result	Accreditation Yes/No	Clear view on point of Improvement , ambitions
Way of Assessing	Verification points: Good/moderate/insufficient Final opinion Good/not good	Orientated around activities total quality care

Comparing the objects of the accreditation (according to the HBO-council) and EFQM makes it clear that the accreditation process sets high standards to process management and Staff, Student, Work field satisfaction and impact on society, (Kemenade, *2001*), the main focus is directed towards process management. Within this, the question whether the curriculum is of sufficient HBO-level. Next to this questions are asked to educational policy and prefixes. The verification points from out of the accreditation are more operationalized than the posing of EFQM. EFQM gives fewer standards with respect to "HBO-level", "assessments", and "methodological requirements of evaluations". EFQM therefore gives more attention toward suppliers and competitors.

Reorganising the EFQM model into the form of a circle, supplemented with the model "Design of Education", in which to a certain extend the specific educational objectives are guaranteed, especially the items of process management, see figure EFQM appraisal. Two phases, the design and the practice are combined within a continuous process. This figure shows the individual elements, which are to be assessed, starting from out of the design process toward the evaluation. All specific elements important for education are mentioned separately.

If these two departure points, are joined together, both the EFQM model, figure, EFQM, as well as the EFQM appraisal, figure EFQM appraisal, the PDCA cycle, Plan – Do – Check – Act cycle is there to come into being.
This PDCA cycle, because of the fact that the individual items can be assessed separately, is the instrument, which will be used.

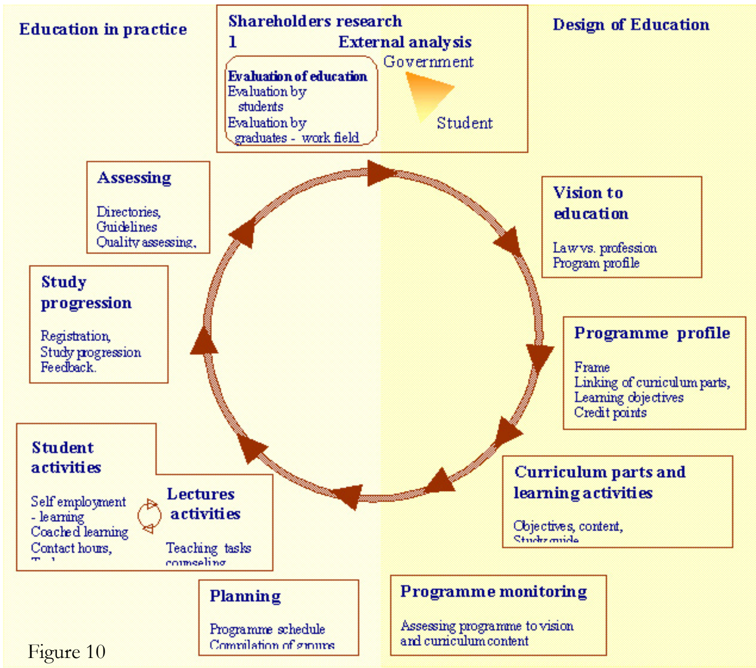


Figure 10

Figure . EFQM appraisal
Version june 2nd 1999, L.Heuvelmans E. van Kemenade.
(source: Methode voor kwaliteitsverbetering van het hoger onderwijs naar het EFQM model.

2.2.2 *The PDCA cycle.*

As already mentioned earlier, "Quality requirements of a Bachelor level course" ten quality requirements are being assessed. This assessment will take place using the PDCA cycle (figure 10, PDCA cycle) as a quality measurement tool. This PDCA circle describes the process of a continuous improvement of education as well as content as process concerned. After making plans an implementation phase is provided. After implementation, measurements are taken and analysis of this data is executed. The PDCA cycle consists out of six phases namely, Planning/ integral improvement, Implementation, Measurement, Feedback, Integral analysis measurements, Development integral improvement, and than again, Planning, etc.

Planning.
Every academic year a planning and procedures are drawn, (if necessary adjusted) of the measurements, which will be taken. Analysis, which were made, and the follow up must be described.

Implementation / Execution.
Execution means, the education, curriculum bringing into practice. The development of research instruments. For example, formulate questionnaire by experts of the curriculum, researchers and a consultant of the Project Quality Assurance of the Fontys University.

Measurement.
A member of quality control of the university will take care of the measurements as planned, using questionnaires, reviews, analyses etc. Main issue here is to retrieve information from students, lecturers, work field and graduates.

Feedback.
Te researcher of the Project Quality Assurance of the Fontys University will process the data and is also preparing an analysis.
Feedback of the results of this analysis will be given. In this case

Measurements, which are taken from	: feedback will be given to:
Students	: Student consultation
Teaching staff	: Teaching staff (collective, individual)
Alumni	: Alumni society
Profession	: Advisory board
Management Board	: Audit and control

This integral analysis of the measurements taken, lead to the development of plans for improvement. The whole system is continuously and constantly running.

Integral analysis
The results of the various measurements are linked together. It is of importance to make cross links The overview of these links and cross links are showed in the matrix, figure 11, connections can be mad in a horizontal or vertical way but also in a diagonal way and will result into management documents. The outcome of the integral analysis will form the basis of an integral improvement plan.

Results Measurements Work field	Results discussion board of advisors	Results former questionnaires	Publications work field developments	Curriculum profile	Final project policy	R&D policy
Results measurements graduates	Results discussion alumni society	Results former questionnaires	Analysis final project dissertations	Visitation report Examiners committee	Inspection report.	HOOP.. Final project coordinator
Results measurements students	Results conference	Results former questionnaires	Outcome Fontys questionnaire	Selection guide HO	Visitation report Assessment analysis	Mentor/lecturer IOWO OCW
Results measurements lectures	Results conference	Results former questionnaires	Results questionnaires staff	Publications HMR	Outcome student questionnaires	Policy HMR
Results consultations reflection group	Results former con discussions	Relevant policy	Visitation rapport	Material goods	Selection guide HO Student questionnaires	Reaction directors management

Figure 11: Matrix integral analysis.

Developing integral improvement
After collecting all the required data, analysing this data as pointed out, conclusions will be drawn for the benefit of an integral improvement plan, which must be discussed whit the education committee, institution participation committee and director of the institute. After receiving the advise of the, mentioned committees, the advises and plans must be implemented.
After implementations the whole cycle starts all over again.

3 Discussion and conclusions, suggestions for further research

After a number of attempts in 1999 a cooperation between Fontys University of professional education and the Catholic University Kempen (KHKempen) has been effectuated in relation to a common orthopaedic technological curriculum In February 2000 a formal approval has been asked to the Dutch government which has this acknowledged in may 2000. The new designed curriculum started in August 2001.
An answer has been found to offer a curriculum in the area of prosthetics and orthotics at the level of Bachelor. undergraduate level.
One of the main goals in cooperation between Fontys and the KHKempen, offering for the Dutch speaking students an approved, recognised and subsidized curriculum at the level of university education, in which the realisation, research and developing takes place in cooperation with each other, has been accomplished.

Also the area of competence and competence development has been described in order design tools to be able to distinguish what makes a graduate an orthopaedic engineer.

A marking fact is that this new developed curriculum takes four years.
Compared to other curricula, it can be said that most of the other curricula are not that length in years. Study load and contact hours are when the study duration in years is taken into account on average equal.

Also time spend on clinical combined with practical internship and final project work reasonable equal, although compared to the other curricula a somewhat smaller part of the curriculum is reserved for clinical hours in the university itself. The main conclusion for this designed curriculum therefore is that taking the analysis and directives of Dutch educational law into consideration, this is a sound orthopaedic curriculum based on a firm fundament, which is also under a consequent evaluation and quality assurance.

The availability of problem based learning methods is also widely included, although a large variation in number of study hours did occur. In our experience working with competences in an educational surrounding does give more justice in the performance of an orthopaedic engineer then a number of single final attainments.

Firstly, introduce a small practical period (1 day) in an early stage of the study, (in the first semester) to give students the opportunity to "experience" the prosthetic and orthotics work field. This will be realised in the curriculum for 2004-2005.

Looking into the future only one thing is certain; changes in the curriculum will take place. When the accreditation system in Europe is in full progress, one can imagine that a new discussion will take place about the length in years of study programmes. If most of the HBO-level programmes take 3 years, why must it take 4 years in the Netherlands? Of course, the outcome of this discussion will have an effect on the orthopaedic curriculum.
Also changes will take place after quality assessments and consultations by professional bodies like the ISPO.

Items which will be worth while to do further research on can be describes as:

- What will be the effect on domestic educational reforms in the cooperation between the two partner Universities, in the near future?
- What can be expected of developments in the profession both national as well as international and how will this take an effect on the newly developed curriculum.
- Design an evaluation tool, which can be used in comparing different curricula in order to get an objective picture of the quantity and quality of the variety of curricula.

4 Appendix I

Mindmap