Towards flexible programmes in higher professional education

An operations-management approach

Open University of The Netherlands

Educational Technology Expertise Center

Info: www.ou.nl/otecresearch

ISBN: 90-9018015-x
Print: Datawyse Boekproducties Maastricht
Graphic design advice: Vivian Rompelberg
Cover image: Charly Chaplin in *Modern Times* (1936)
Modern Times © Roy Export Company Establishment

Contents

Chapter 1. General introduction

Nowadays, flexibility is perceived as an important factor in education. In educational policy, increasing the flexibility is considered as a solution to educational and practical problems, for instance, to improve the quality of education by adapting educational programmes to the needs of individual students, and to increase the cost effectiveness of educational institutes. This dissertation addresses educational problems related to the low degree of flexibility of educational programmes in higher professional education (HPE). In an interdisciplinary approach, concepts and tools from the field of operations management were adopted to optimize educational programmes by increasing their flexibility. In this approach, operational systems and processes are considered as crucial factors for the implementation of many innovative concepts and ideas in education.
First, this introduction explores recent developments with respect to intended innovations and their effects on the flexibility of educational programmes in the field of HPE in The Netherlands. Second, policy needs for flexible educational programmes are considered in order to determine how increasing the flexibility can contribute to educational aims, and which aspects of flexibility are involved. Third, operations management is introduced as a framework to be used for the study of operational systems and processes in education, and to offer concepts and tools for increasing the flexibility of educational programmes. In particular the role of simulation modeling is explored. Fourth, the main components of our research approach are described: a survey study to explore the flexibility and operational characteristics of educational programmes in HPE institutes; two case studies using simulation to develop and test flexible operational models for educational programmes, and an expert validation of the flexible educational model. Finally, the structure of this dissertation is presented.

Innovations in HPE

Currently, many HPE institutes in The Netherlands are involved in revisions of their educational programmes. Schellekens, Nagtegaal, Schlusmans, and Kinkhorst (1997) found that these revisions serve educational as well as practical goals. Although scopes and priorities may vary, the arguments for intended innovations primarily suggest educational motives, such as the introduction of 'competence-based learning', 'action learning', or 'e-learning'. Schlusmans, Kinkhorst, Nagtegaal, Van Vilsteren, & Schellekens (1998) state that innovations in HPE have several characteristics in common: integrating theory and practice, activating students and giving them more responsibility for their own learning, promoting coaching in favor of teaching, increasing the productivity of learning activities, customizing programmes to individual students, removing obstacles to effective and efficient study, and using new technologies. A closer look reveals that these revisions concurrently take additional, secondary motives and circumstances into account, such as the need to attract more students, to reduce the number of programmes and departments, to combine programmes having

insufficient numbers of students, to develop new programmes for specific student segments, and to spend additional funding available for innovations. These additional motives mainly seem to indicate operational aspects, which generally are related to efficiency and financial means. In accordance with other authors (Van den Berg, 1996; Van den Born, 1997; Van Meel, 1997), it could also be noticed, that many revisions aim at increasing the flexibility of educational programmes. It is plausible that flexibility also is characterized by educational as well as operational aspects.

Educational aspects of flexibility
Considering the educational aspects, the revisions show a number of specific developments in educational programmes. Institutes have taken into account changes in the needs of the relevant professional fields, using new professional and educational profiles from representative organizations for redefining the available curriculum and the related contents. Instead of focusing on specific disciplines, subjects and skills, educational programmes are reconfigured according to a more integrated approach (Van den Berg, 1996; Schellekens, Paas, & Van Merriënboer, 2003). Taking into account the primary innovative aims, the knowledge and skills to be acquired are carefully arranged in a structure of thematic programme blocks and study modules. The teaching staff is organized in dedicated teams for developing these programme blocks and to become responsible for the education in these blocks, making teaching a team-oriented instead of an individual activity. Teaching in classroom-based lesson hours is considerably reduced in favor of group assignments, coaching, and independent study activities. Study materials are adapted to this new approach in order to pre-structure and support the activities of the students.

Effect. The effect of these changes in educational programmes can be regarded as positive for some aspects and negative for others. On the *positive* side, knowledge and skills are acquired now in a more integrated, practice-oriented and productive way. Students have become more actively involved and responsible for their learning activities than before. The activities of teachers and students are more interactive: students can learn from each other and benefit from the multiple qualities of the teachers involved in a team. Study materials are more elaborated and gained quality for the support of the students. Teaching and learning show more variation, and new information and communication technology (ICT) is introduced. On the *negative* side, thematically integrated programmes distribute the main disciplines and subjects among distinct programme blocks, making them dominant in one or a few blocks and almost absent in other blocks. More general and supportive disciplines, such as language and computing skills, are often concentrated in just one programme block, thus restricting the opportunities for integration in the programme as a whole. The development and teaching of programme blocks by dedicated teacher teams creates a risk for maintaining the coherence in a programme. Teaching in block-oriented teams restricts the influence of individual teachers to the programme blocks they are actually involved in. Concentrating curriculum components in specific programme blocks means that no block in a programme and no topic in a block can be left out, making careful evaluation and formal assessment more necessary than before. The thematic

integration is counteracted by the need to divide programme blocks in distinct parts to be credited, in order not to disturb the study progress of students. The formerly direct responsibilities of individual teachers for specific disciplines and year groups of students, are replaced by indirect and less traceable team responsibilities. Teacher roles in teams have become less evident and tangible for the students. Reducing the number of formal lessons in schedules has loosened the formerly stringent time constraints. Supportive study guides tend to formalize education and learning in detailed prescriptive procedures. The traditional discipline-based organization of the teaching staff has been abolished and was replaced by an organization in thematic programme-block teams.

Operational aspects of flexibility
Many of the aforementioned educational changes have operational consequences. Although intended educational innovations have been realized to a certain extent, contributions of several authors (Clarke & James, 1998; Schellekens et al., 1997; Van den Berg, 1996) have made clear that already existing operational problems have not yet been solved and new problems have been created. Schellekens et al. (2003) established that major changes in educational aims, contents and scope are not accompanied by corresponding changes in the operational structure of educational programmes. Leaving conventional programme structures and procedures unchanged, may cause serious friction with newly implemented educational changes. Increased variation in study and support activities, for instance, puts serious pressure on the conventional scheduling of lessons, which usually has been maintained despite the reduced number of formal lesson hours. Diminishing the former classroom-based approach in favor of small-group learning and individual coaching may threaten the efficiency of education in several ways, for instance, by repeating the same instruction more frequently and by using the still available classroom facilities for small group activities. ICT is often presented as a solution for this kind of problems (e.g., Danish Ministry of Education, 1994). But it was found that ICT neither replaced existing educational functionalities nor added new educational functionalities to teaching and learning. Without changing the educational approach, an increased availability of ICT facilities can easily be misused by students just for grading purposes. Generally, ICT facilities have improved the quality of procedural information by making it more up-to-date and increasing its availability, for instance, by customized lesson schedules. However, information that formerly has been available in printed study guides often has become less structured and reliable.

Effect. Focusing more specifically on the operational effects of these developments, one may find that maintaining the usual operational format of education severely restricts the flexibility of educational programmes. The aim to adapt programmes to the specific needs of individual students has not been realized and the opportunities for programme differentiation are still limited. Exemptions and missed study units (e.g., caused by illness) usually hamper the study progress of individual students. Dividing the curriculum content over programme blocks combines and freezes this content in a much more inflexible fashion than before: skipping specific programme parts has become nearly impossible. Packaging programmes in distinct blocks makes it

difficult to change the aims and contents of existing programmes, and to create new programmes.
Increasing the flexibility of educational programmes currently is still an important aim for many innovations, not only for the students, but also as a demand of the professional and societal environment. Actual developments, surprisingly, indicate that the flexibility has been reduced instead of increased (Schellekens et al., 2003; Van den Berg, 1996). The next section of this General introduction further explores the need to increase the flexibility of educational programmes and the aspects of flexibility involved.

Flexibility of educational programmes

In this section, two complementary perspectives on the flexibility issue are considered: the educational policy for performance improvement addressed to educational institutes, and educational innovation as perceived within educational institutes. From these two perspectives, educational programmes and their flexibility are positioned in educational theory.

A policy problem: Improving the performance of educational institutes
In the last decade, HPE institutes in The Netherlands have been involved in a process of institutional merging, concentration, and scale enlargement. Policy aims were cost reduction and improved conditions for quality and innovation. These processes lead to more financial and administrative autonomy of the institutes. Many of the new large-scale institutes are still segmented in relatively autonomous departments which offer their own educational programmes. Creating a new educational programme usually requires a new department, which generally is a costly operation (e.g., Baeten, 1998), and a minimum number of students to start with, for reasons of cost effectiveness. Governmental policy statements indicated that to meet the expected demands of the labor market, the number of students in HPE programmes must increase, which would require a performance improvement of the institutes involved. New categories of students must be attracted, for instance, secondary level vocationally trained professionals (Dutch: MBO), unemployed higher trained professionals, and ethnic minorities (Ministerie van Onderwijs, Cultuur en Wetenschappen, 1997).
To meet these demands, the Minister of Education has decided to introduce more variation in educational programmes and to support lifelong learning. Flexibility is mentioned as a key concept for educational policy in the coming years. Increasing the flexibility of programmes in institutes for higher education is expected to create better conditions for educating growing numbers of increasingly different categories of students, which can be further reinforced by a rising interest in lifelong learning. Recently introduced financial regulations allow students to combine study and work, which will further increase the need for flexibility of educational programmes (Hermans, 1998).
In conclusion it can be said that improving the performance of educational institutes is considered mainly as solving an organizational and economic problem. Increasing their flexibility is seen as a way to solve that problem.

An educational problem: Increasing the flexibility to support innovation

To meet the external demands and expectations of educational policy, HPE institutes aim at performance improvement, but their efforts must also meet own criteria related to the quality of education and intended innovations. Competence-based learning is often seen as a key concept for innovation in higher education, covering characteristics as integration of traditional study disciplines, self-directed learning, and coaching. To introduce innovative changes in HPE, new educational programmes are developed, which intend to cover these and other related principles (Schlusmans et al., 1998). As professional competences can be considered as complex skills, the four-component instructional design model (4C/ID; Van Merriënboer, 1997) can be applied for designing these programmes. According to the 4C/ID model, competence-based learning must focus on task-directed activities (considered as integrated, 'whole' tasks), which need to be supported by knowledge- and skill-directed activities. But the implementation of this approach in new, competence-based educational programmes meets a serious problem: the usual thematic approach, in which the former discipline-based programme units were clustered into large comprehensive programme blocks, causes a serious loss of flexibility (Van den Berg, 1996).

To solve this educational problem, several questions can be asked. How can task-directed activities be organized without loosing flexibility? Competence-based learning, which is no longer structured along the lines of traditional study disciplines, still needs support of these founding disciplines. How can knowledge-directed activities be organized in an effective and efficient way? Students may differ considerably in the mastery of instrumental skills and related knowledge in order to develop the professional competences they need. How can skill-directed activities be organized to allow for customized educational programmes? Underlying these questions is the more general problem how educational programmes, which in many cases still are defined in terms of fixed time schedules (year, semester, block, week schedules), fixed student cohort groups (year groups), and predetermined activity schedules, can meet the needs of increasingly different categories of students and allow for self-directed learning of the individual students (Schellekens, 1998). These questions underline the relevance of increasing the flexibility of educational programmes from an educational point of view. Increasing the flexibility can contribute to the customization of educational programmes to the differing needs of individual students, and to improve the conditions for innovations related to competence-based learning (Schellekens et al., 1998).

Solving problems related to educational innovation must be considered as a complex issue, covering not only educational and organizational aspects, but also economic, social, cultural and other important aspects. In full recognition of its complexity, this study focuses on one specific aspect of the problem: increasing the flexibility of educational programmes is considered as a specific organizational problem to be resolved by managers of educational institutes in a context of innovative competence-based learning. The results can be used to gain insight in the effects of operational changes in educational programmes and to support decisions about increasing their flexibility.

What is flexibility in education and how can it be increased?
A definition of flexibility may refer to several aspects of educational programmes, for instance, needs of students, educational support, and programme design. Flexibility with respect to needs of individual students covers topics like varying contents, sequences and study methods to meet personal interests, preferences and circumstances. Students may skip already mastered programme units due to prior knowledge in order to avoid loosing time. Study time for specific units or whole programmes may vary individually. Waiting periods could be avoided or reduced by allowing students to start courses and programmes when they actually need them. Flexibility with respect to educational support is concerned with topics like educational programming (content and sequencing), didactic approach (way to learn), organization (time and place), and available resources (material and human). These topics are interrelated to each other in several ways and the management of the institute must be involved (Van den Born, 1997).
For flexibility in educational design, 'curriculum' and 'programme' are key concepts. According to Pratt (1980), a curriculum is an organized set of formal educational or training intentions, which includes elements like aims and objectives, selected contents and organization, patterns of learning and teaching, and evaluation of outcomes.
A curriculum must form a consistent system that may be influenced and characterized by certain learning theories and societal developments. An educational or training programme can be considered as an implementation of a curriculum, leading to a specific sequence or set of learning activities, including the use of materials, equipment, teacher support and other facilities. Kessels (1993) describes the concept of the operational curriculum: “It consists of the factual learning situations that are created, the interaction between trainer and trainee, the trainee working with the curriculum materials, and the learning processes that occur. The operational curriculum can be found in classrooms, in practical work supervised by a coach or carried out independently by the trainee, in special projects, in doing homework, in a simulated work environment, etc.” (Kessels, 1993, p. 23). Increasing the flexibility in educational programmes can seize at the operational curriculum and focus upon the organization of learning situations and the planning of learner and support activities. Following this concept, operational flexibility refers to the flexibility of operational processes in the organization of educational programmes, for instance, considering curriculum structure, timing, placing, grouping, and assessment as relevant aspects. To increase the operational flexibility these aspects must be taken into account.
Increasing the flexibility of educational programmes requires a comprehensive educational framework. Educational design theory offers a framework and concepts, which may help to define changes and innovations in educational programmes. The concept of competence-based learning, for instance, can be used to redefine the curriculum structure, replacing a discipline-based programme structure by a more suitable structure for competency development. Other concepts may lead, for instance, to a focus on self-directed learning and addressing students' own responsibilities (Everwijn, 1996). Breaking the current almost one-to-one connection of curriculum and programme, can be used as an entry to envision new possibilities for increasing the flexibility of educational programmes.

In conclusion, the primary aim of the present study is to support managers of HPE institutes in gaining insight and making decisions for increasing the operational flexibility of their educational programmes. A next question is, were to find support for increasing the operational flexibility of educational programmes.

Operations management

The field of operations management studies organizations with respect to their operational aspects. Does operations management offer a useful framework to study the flexibility of educational programmes and an approach for increasing the flexibility of educational programmes?

Operations management as a framework to increase the flexibility of education
Operations management covers a body of knowledge grown out of disciplines as operations research and industrial engineering. It focuses on organizations and their operations, where the term 'operations' refers to the use of resources (e.g., capital, materials, technology, human skills and knowledge) for the production and delivery of goods and services. Operational systems are considered as means to reach performance goals of industrial and service organizations, as well as the goals of their customers. Operational processes are the primary processes of organizations set up for delivering products and services. Typical phenomena under study are, for instance, planning, scheduling and sequencing of processes; workflow, process and resource modeling; and control procedures. Systems and processes can include the management of materials and human resources (BETA, 1999).
Can operations management, which is grounded in industrial and service organizations, help us to increase operational flexibility of organizations in education? Examples of applying an operations-management approach for improving educational systems and processes are rare (e.g., Verbraeck, 1991). On the other hand, in industry numerous studies have shown that flexibility is an important issue in the manufacturing of products (e.g., Geraerds & Igel, 1989; Weiss & Gershon, 1989). In that context, flexibility is defined as the capacity to deliver custom-made products within a short time. Flexibility can be increased by reducing waiting times, for instance by a new product design, by reorganizing production processes, or by combining operations (Bertrand & Wijngaard, 1989).
Service organizations, such as banks, hospitals and restaurants, are another object of study in operations management. Compared to manufacturing organizations, service organizations seem to have more traits in common with educational institutes. A main aim of service organizations is to serve the varying needs of their customers. Other characteristics are, for instance, that customers are considered as participants in operational processes. In service organizations, production and consumption processes often occur simultaneously. Services are usually labor intensive, and managing capacity in time is an important aspect (Fitzsimmons & Fitzsimmons, 1994). In operations management, service organizations are a well developed object of study. Vissers (1994) has developed a method for managing hospital capacity in order to optimize the coordination of services. De Vries, Bertrand, and Vissers (1999) studied the design

requirements for health-care production-control systems, such as hospitals. In a more general approach, Fitzsimmons and Fitzsimmons (1994) have addressed the improvement of service systems and processes by means of operations management techniques, covering topics such as organizing human resources, scheduling, customer participation, queuing systems, programming models, and quality control.
Summarizing this exploration it is concluded that operations management represents a substantial body of knowledge that is relevant for studying operational systems and processes in education, which leads us to our next question.

How can operations management contribute to increasing the flexibility of education?
Research approaches in operations management cover the analysis, design and control of operational processes (BETA, 1999). 'Analysis' aims at a better understanding of operational systems and factors that influence their performance by means of modeling and validating these systems with empirical data. 'Design' aims at the prototyping and testing of systems, including all relevant aspects of their operational processes. 'Control' focuses on the measuring and improving the performance characteristics of operational processes. Similar to areas such as manufacturing and health care, it is expected that operations management can be used to analyze and model current educational systems, to prototype new systems, and to control processes in HPE settings. New concepts and ideas from the field of operations management may contribute to study education in order to increase the operational flexibility of educational programmes. A hospital is, due to the actual notorious reputation of waiting lists in Dutch health care, a provoking and interesting metaphor to be considered here, assuming that it delivers its services in a much more flexible way than schools normally do. Hospitals offer, for instance, a repertoire of treatments (cf., curriculum) and customize their services (cf., programmes) to the needs of individual patients (cf., students). Specialist departments (cf., discipline groups) take care of specialized treatments (cf., courses, lessons) and related facilities (cf., teaching staff, classrooms). A patient dossier (cf., student portfolio) contains data about treatments (cf., programmes) and observed effects (cf., study results). Despite some differences (e.g., students are more active participants than patients), hospitals and other service organizations have interesting features in common, which may appear helpful for increasing operational flexibility in educational institutes.
A wide range of powerful methods and tools is available in operations management, which can be used for analyzing and modeling operational processes (e.g., by simulation), in order to support the design, development and testing of improved or new systems (Anderson, Sweeney, & Williams, 1994; Hillen, 1995). MedModel (1999), for instance, is a software package for system modeling, simulation and optimization, aiming to support decision making in the design and management of operational systems and processes in health care and hospital settings. In a comparable way, methods and tools from operations management may be used in educational settings. Specific operational problems can be analyzed, new solutions developed, and new systems and processes designed and controlled in order to contribute to optimizing important conditions for innovation in education. In the long term, as proposed by Ball, Datta, and

Dahl (1992), more generic tools may be developed for supporting operational decisions which are needed to manage flexibility related issues in HPE institutes.
It can be concluded that the contribution of operations management to the current research project will mainly be instrumental, delivering the concepts and ideas, tools and methods to analyze, model and test operational solutions for problems related to flexibility in the organization of education. In the next section, the research approach and its components will be introduced.

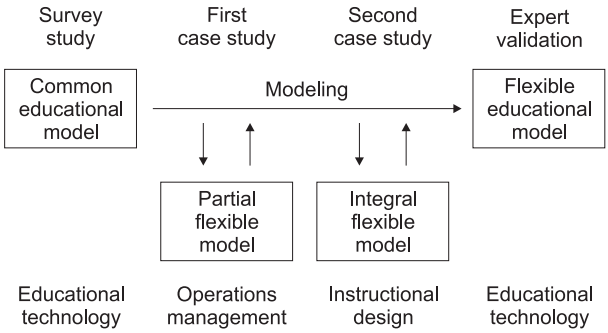

Figure 1. Research approach.

Research approach

The preceding elaboration of the flexibility problem leads to the main research question: "Can operations management yield solutions for the lack of flexibility in educational programmes, which are accepted by educational managers as actually supporting educational innovation?" To answer this question the research approach will focus on the question, how to organize competence-based programmes, when they are looked upon as task-directed activities supported by knowledge- and skill-directed activities. This problem is considered as indicative for a wider range of problems related to operational flexibility in education. Solutions are expected to create better conditions for innovations such as competence-based learning. Thus, increasing the flexibility of educational programmes goes hand in hand with supporting educational innovation, aiming at the development of optimized educational models which can be based on curriculum reconstruction. A core curriculum of task-directed activities, based on flexible grouping of students is supposed to create an important condition for competence-based learning. Knowledge- and skill-directed activities need to be organized in an effective and efficient way to adequately support the task-directed activities. Increased flexibility will be established mainly in terms of criteria for educational programmes which are customized to the needs of individual students. Given students with different profiles, it is supposed that flexibility will have a diverging effect on the time that students need to complete their educational programmes, according to the modeled solutions. In this research approach, modeling of educational systems and

processes for increasing the flexibility of educational programmes is a core activity, which is meant to span a bridge between the educational problem setting and the operations-management approach in order to test our hypothesis. An incremental approach is followed to tackle the complexity of the flexibility problem, which allows to build up experience and to explore and improve the problem solving approach. Therefore a sequence of four studies was conceived: a survey, two case studies and an expert validation, which is illustrated in Figure 1.

First, a survey study was carried out in order to obtain a clear picture of the operational characteristics and flexibility of current educational programmes. For this study, a preliminary educational model ('Common Educational Model') was developed to be used as a framework for analyzing the operational systems and processes. The survey data served as a reliable context for the positioning of the case studies, which served to describe and analyze the specific educational systems of the institutes, to develop new educational models, and to determine criteria for increased flexibility in order to favor competence-based learning.

Next, two case studies were situated in specific educational institutes to offer adequate opportunities for defining specific educational problems, to model and analyze the involved systems and processes, and to develop and test solutions for increased flexibility. In the first case study, the flexibility of the programmes was increased by organizing the skill-directed activities of the curriculum in an individually organized programme part, leading to a 'Partial Flexible Model'. In the second case study, the curriculum was reconstructed according to a competence-based approach in which knowledge- and skill-directed activities were organized to support task-directed activities, leading to an 'Integral Flexible Model'.

In both case studies, a faculty in Business Administration (BA) of a government-funded HPE institute was involved. The educational problems to be solved, were restricted to specific operational problems and solutions for increased flexibility. Solutions were determined in formalized models of operational systems and processes, which were focused on the operational characteristics involved in increasing the flexibility of educational programmes. Simulation was used to model and test educational solutions with the use of real data derived from the case settings. Problem definitions and solutions were validated by educational managers of the case institute (internal validation).

Finally, an expert validation of a more generic 'Flexible Educational Model', which was derived from the second case study, was carried out to gather further evidence for the tenability of our hypothesis. In this external validation, experts in educational technology and higher-education policy were involved.

Structure of the dissertation

This section gives an overview of the succeeding chapters of this dissertation and summarizes the main issues of the activities in our research approach.

Chapter 2 describes the survey study and the 'Common Educational Model'. The developments in The Netherlands with respect to innovation and flexibility in education are considered in the context of the need for a common higher education system within the European Union. The survey was prepared by developing a preliminary educational model, which offered a conceptual framework and working definitions of flexibility. The study aimed at gathering data concerning the operational characteristics and the flexibility of educational programmes in higher education. The BA departments of 22 government-funded HPE institutes were involved, together offering a major part of the educational programmes in this field in The Netherlands. The survey was addressed to the managers of the BA programmes.

Chapter 3 describes the first case study, in which a partial flexible model was developed for a medium-sized HPE institute. In search for principles to increase flexibility, educational institutes were positioned in an operations-management framework and analyzed with respect to their flexibility. A process-focused strategy was found useful to customize educational programmes for individual students. The main aim of the case study was to develop an operational model for a simulation experiment, in order to increase the flexibility of the skill-directed activities in the programmes. The BA programmes were analyzed to determine the curriculum units for developing instrumental or supportive skills. For these units, a partial curriculum was defined and organized in a separate, individualized programme stream. The other curriculum units remained organized in a thematic programme-block approach. In a simulation experiment, the original programme was compared with the newly developed, individualized programme.

Chapter 4 presents the second case study, in which an integral flexible model was developed for the BA department of a large HPE institute. Flexibility was reconsidered, extending the range of relevant aspects to be taken into account for redesigning educational programmes. An important educational aim was to bridge the conventional borders between learning and work. Operational flexibility was specified in a number of criteria that flexible programmes should meet, in order to customize these programmes to the needs of individual students. Principles were formulated for designing new educational programmes, using findings from the fields of operations management and instructional design. In the case study, a comprehensive, process-focused and demand-driven operational model was developed following these new aims, principles and criteria. In this integral flexible model, the curriculum was reconstructed in order to create a core programme of task-directed activities, supported by knowledge- and skill-directed courses.

Chapter 5 describes the expert validation of the Flexible Educational Model. This model was derived from the integral flexible model of the second case study by refraining from the actual aims and constraints of the case-study institute. New organizational possibilities of the programme characteristics with respect to flexibility were taken into account. Expertise from the field of educational technology was used to propose implementations for important aspects of new educational systems, such as the roles of students and teachers, curricula and programmes, infrastructure and facilities. Findings of a recent international study on flexibility in the field of vocational and educational training (VET) in the European Union (Nijhof, Heikkinen, & Nieuwenhuis, 2002) were considered. The results of the validation of the Flexible Educational Model by educational experts are described.

Chapter 6, to conclude, discusses the aims, approach, results and conclusions of our research project. The perspective for further activities in developing the issue of flexibility and innovation is explored.

Chapter 2. A survey in BA programmes in The Netherlands[1]

In order to develop higher education in the European Union there is a need to increase the mobility of students and teachers. Improving the flexibility of educational programmes is an educational policy in The Netherlands to support this development. To get a clear picture of the operational characteristics of current educational programmes, their flexibility and conditions for improvement, a survey was carried out in business-administration programmes in HPE institutes in The Netherlands. The results indicate that these programmes are organized in rather rigid operational formats that seem to restrict flexibility. The issue of developing new operational models that allow for more flexible educational programme formats is discussed. Operations management and educational technology are considered as potential domains for a re-engineering of educational systems.

The creation of a European area of higher education is a key way to promote the citizens' mobility and employability and the continent's overall development. Institutes for higher education have set a course to achieve greater comparability and compatibility of the national systems of higher education in Europe and, ultimately, one European system of higher education that is worldwide competitive (Sorbonne declaration, 1998). Goals have been set to create a common higher education system with a bachelor-master structure (cf. the US system) and comparable degrees and credits in order to promote the mobility of students, teachers and staff (Bologna declaration, 1999).

Higher education in The Netherlands is closely following the European trends in developing a bachelor-master structure of four or five years, possibly followed by a doctoral level degree or professional qualification study. In The Netherlands, government-financed higher education consists of institutes with either an academic orientation (universities) or a professional orientation (higher professional education institutes). In the study year 1997-1998 about 441,000 students participated in higher education, 280,000 of them in HPE institutes. By far the largest sector in HPE is the field of business administration (BA) with 85,000 students (Centraal Bureau voor de Statistiek [CBS], 1998, 1999). Regular HPE institutes mainly offer initial BA degree programmes. Information about the higher education system in The Netherlands and in other European countries is available in the EU database 'Eurydice' (Eurydice, 1980).

In 1999 it was expected that until 2003 a growing Dutch labor market will need an extra 150,000 HPE graduates (Research Center for Education and the Labor Market, 1999). In the year-2000 policy statement for higher education (Ministerie van Onderwijs, Cultuur en Wetenschappen [MinOCW], 1999) was argued, that improving the flexibility of education may provide an important means to attract more students to

[1] Based on: Schellekens, A., Paas, F., & Van Merriënboer, J. J. G. (2003). Flexibility in higher professional education: A survey in business administration programmes in The Netherlands. *Higher Education, 45*, 281-305.

HPE institutes, including new categories of students. Other arguments state, that study success is expected to improve by allowing students to combine study and work and by providing adequate study support. Extending the scope of education to lifelong learning and a growing international orientation are considered to increase the employability of students and their readiness for a dynamic labor market. The national council for science and technology advises universities and HPE institutes to cooperate in order to improve the accessibility of new knowledge and skills for the students (Adviesraad voor het Wetenschaps- en Technologiebeleid, 1997). These and many other intended, recommended or expected developments may all result in a greater variety in student populations and consequently increase the need for flexibility in educational programmes.

Improving the flexibility in education is expected to become a key issue in educational policy. Within Europe, improved flexibility is perceived to smoothen differences between the official national higher education systems in order to remove, mostly, formal thresholds for studying in other European countries. In The Netherlands, more flexibility is needed to increase the capacity of the higher education system for a larger and more varying student population. For these and other possible examples, the concepts of flexibility and the means that are perceived to improve it, seem to differ. For our purpose, we start with a common sense definition: Flexibility is considered as the extent to which students can get an educational programme that fits their educational needs within the normal conditions of an educational institute.

Considering approaches aiming at increased flexibility, Johnston (1999) states that increasing the flexibility in education is found an effective strategy to widen the access, greater equality of opportunity and breakdown of the barriers between learning, working and leisure. Van Meel (1992) considers *in*flexibility as a structural phenomenon of educational organizations, caused by the convergent approach of professional bureaucracies translating new problems into familiar frames. She expects that modularisation and part-time programming will contribute positively to flexibility (Van Meel 1997). In the EU Telescopia project, Collis, Vingerhoets and Moonen (1997) studied the use of telematics-supported learning events in training environments throughout Europe, aiming at more flexibility for the learners. To reveal the dimensions of flexibility, Clarke and James (1998) studied post-registration nurse education in the UK. Starting from a definition of 'flexible learning', they used a survey and case studies for an in-depth exploration of programmes and modules. They identified forty-three dimensions in flexible learning and conclude that it is a multidimensional concept, which is open to a range of interpretations. Many of these dimensions point out to be related to the operational aspect of education: the ways in which students, teachers, equipment and facilities are arranged and interact for the purposes of education.

In The Netherlands, many developments and innovations of the past decennia undoubtedly have changed HPE programmes in many ways. But the operational characteristics of educational programmes do not seem to have changed really over all these years. Educational programmes still find a solid basis in laws and legal regulations that, for instance, define current HPE programmes in a four-year study programme with a study load of 6720 hours. A study year is organized in standard study periods, lessons are planned in weekly schedules, and students participate organized in year-group

classes. Educational settings are still typical school settings, which do not have much in common with the job settings students are prepared for. A comparable picture can be found in other European countries, which almost all define their programmes in study years; typically, programmes are organized in academic years starting in August, September or October. Most countries use a two-semester structure, but in The Netherlands a structure of four or five modular blocks is used (Haug, Kirstein & Knudsen, 1999).
Converging towards a common higher education system in Europe, may lead to the acceptance of this dominant model of academic years and fixed study periods. But from the viewpoint of a desired flexibility in educational programming, one may seriously question this development. To start or change a study programme, for instance, students often have to wait many months for a new academic year to begin. Organizing degree programmes based on a four-years pattern and in year groups seems inadequate when, for instance in The Netherlands, only 35% of the students (full time, cohort 1991) completed a HPE programme in the nominal four years and 56% within five years (CBS, 1998). It may be worth to consider whether a different operational approach in educational programming is possible, that might cause fewer problems.
In this study we focus on the flexibility of educational programmes with regard to the operational aspect (i.e., 'operational flexibility'). Our aims are to look for the operational characteristics of educational programmes in higher education, to determine how flexible these programmes currently are and to explore the conditions available to improve their flexibility (i.e., 'conditional flexibility'). We relate these findings to the subjective judgments of the programme coordinators generally perceiving the flexibility of their programmes (i.e., 'subjective flexibility'). The referred aspects of flexibility are worked out in a conceptual framework.

A conceptual framework for educational systems

From an operational point of view, an educational institute can be considered as a system offering many different programmes, involving thousands of students and their teachers, organized in faculties and departments. But for a closer look at educational programmes in this study, we have decided to take a single degree programme as the unit of analysis. A degree programme is based on a dedicated curriculum and involves all components, such as students, teachers and facilities that are necessary to run that programme.
Using a systems approach (Hall, 1962), actors, activities and results can be taken as basic concepts. Students, teachers, developers, service personnel, etcetera, are all actors (i.e., acting people) in an educational system. They have different functions and roles, which interact in several ways. Actors can be qualified in categories, like full-time and part-time students, generic and specialized teachers, etcetera. Actors carry out activities: Actions with certain functions, which are goal-directed and lead to certain results. Often they cohere in an operational way: A lecturing teacher supposes students who listen, take notes, ask questions, and so on. Any activity involves one or more actors, takes a certain time and happens at a certain moment and place. Activities lead to

results, which are goal-related and can vary considerably, from the students' notes to be used in a learning process to the competence level that students may develop as a long-term result of participating in an educational programme.
Curriculum and programme are specific educational concepts, which relate to educational programming in different ways. A curriculum is a coherent, structured set of goals, related contents, procedures and means that determine the teaching and learning activities in an educational institute. The curriculum may be conceived as a repertoire of activities for students and teachers to reach the goals that are set for the students in order to be qualified for certification. It covers the intentional side that defines an educational system and forms a basis for a concrete implementation of a degree programme (Pratt, 1980). Therefore a programme can be described with the same concepts as a curriculum: A specific selection of activities, which students need to reach their educational goals. Consequently, within the framework of a curriculum there may be as many programmes as there are students.
All kinds of activities, which may appear in many different settings, constitute the operational processes in an educational system. For instance, students solving problems and writing reports or teachers preparing assessments. Group activities at the educational institute and individual student's study activities at home. Teachers lecturing or coaching individual students. Curriculum and programme determine to a large extent how these operational processes in educational institutes are directed and organized.

Characteristics of educational systems
Clarke and James (1998) used a constructivist approach to map the characteristics with respect to flexibility of post-registration nurse education in England. To determine the aspects that may be important to characterize higher education in The Netherlands, we used a comparable approach to analyze the structures and processes in this educational system.
Structural characteristics, for instance, include: facilities, infrastructure, organization, goals and concepts. Facilities cover all kinds of support for the activities of students and teachers, such as lessons, coaching, library services, Internet access and study materials. The infrastructure regards the available locations and temporal and technical conditions, such as lecture rooms, access periods and ICT facilities, which are needed to offer facilities for students and teachers. The organization determines how educational and support processes are arranged, e.g., in faculties and a department for each degree programme. The goals play a role in directing the activities and in the internal and external evaluation of educational and support processes. Educational concepts define the approach of an educational institute and reflects it's position in society. These structural characteristics determine important conditions to enable educational processes.
Process characteristics can be determined in related concept pairs: e.g., information and communication, interacting and grouping, timing and placing, steering and planning, and assessment and evaluation. Each of these characteristics represents an important aspect of a specific programme implementation. Information and communication are important for learning processes and to coordinate students' and teachers' activities, expressed for instance in the roles of teachers and the functions of study materials,

which may change with the use of ICT facilities. Interacting and grouping have an impact on the contacts and activities of students and teachers; differing for instance in a year-group based programme and an individual self-study programme. Timing and placing are necessary to coordinate group activities of students and teachers in educational institutes; changing for instance with new communication facilities allowing cooperation at a distance and in asynchronous fashions. Steering and planning may involve a choice for a centralized steering and scheduling of activities, or for a more individual, demand-oriented approach. Assessment and evaluation represent feedback mechanisms for educational and supportive processes. Assessment may focus on direct learning results (e.g., testing actual knowledge) or on personal competencies that students develop in a longer run. These process characteristics represent choices that determine how educational processes are implemented.

Constructs of flexibility

The structural and process characteristics of educational systems are related to flexibility in a rather complex way. In order to determine and measure flexibility, the underlying data were clustered by four constructs: Curriculum, Activities, Facilities and Environment, each representing a different aspect of flexibility (see Table 1).

The curriculum construct considers how a curriculum is defined and determines an educational programme. The aspect of flexibility considered here, is the extent to which a curriculum allows students to have a customized programme that meets their individual needs and circumstances. "How well does a curriculum allow students to have such a programme?" The activities construct focuses at the implementation of a programme in student and teacher activities. This construct reflects how flexible the actual processes may take place. The activities construct determines how a programme is anchored in specific activities and their planning and organization within the context of a certain curriculum. "How do students and teachers spend their time and how are their activities planned and organized?" The facilities construct focuses at a conditional aspect of flexibility: The means that are available for the implementation of programmes in terms of study facilities, infrastructure and accommodation. "Which facilities are available for the support of the students?" Facilities represent internal conditions for the flexibility of programmes. Adequate study materials, for instance, are needed to facilitate self-directed study activities. An electronic learning environment requires a well-equipped ICT infrastructure. These and other facilities can increase the flexibility of educational processes. But if and how these means do contribute effectively to flexibility, may differ. The environment construct considers how a degree programme is positioned in and interacts with its environment. "How responsive is a programme to its environment and how does the environment react to and support a programme?" A high degree of interaction may increase the responsiveness of a programme to the goals and demands of the environment, which in turn may react by increasing the means to serve these needs. Cooperation inside and outside an educational institute can increase the capacity and results of a programme. Position in and interaction with the environment represent external conditions for the flexibility of a programme.

Working definitions of flexibility

In order to define flexibility, these constructs are used to create two working definitions of flexibility: operational flexibility and conditional flexibility. The Curriculum and Activities constructs represent the structure and implementation of an educational programme. In these constructs the effect of the actual operational format on a programme can be found. Therefore, the combined effect of these constructs is defined as the 'operational' flexibility of an educational programme. The Facilities and Environment constructs reflect the internal and external conditions enabling the flexibility of an educational programme. Their combined effect is defined as 'conditional' flexibility. A difference between conditional and operational flexibility can be considered as a discrepancy between potential and actual flexibility.

Table 1. Flexibility: Working definitions, constructs and topics

Subjective flexibility			
Operational flexibility ('objective')		Conditional flexibility ('objective')	
Curriculum	Activities	Facilities	Environment
Study-period definition	Disciplin orientation	Insititute locations	Number of students
Study phasing	Student-teacher interaction	Study facilities	Number of Teachers
Study-load definition	Lessons	Development facilities	Programme cooperation
Study-unit definition	Group activities	Study materials	External cooperation
Assessment procedures	Use of locations	Software applications	Additional programmes
Target-group orientation	Scheduling	Distance-education facilities	External services
Programme differentiation	Facilities access	Tele-learning facilities	Goals
Enrollment	Accommodation access	ICT infrastructure	Concepts
Exemptions	Study periods		
Grouping procedures			
Programming variations			
Start and stop a programme			
Participation modes			
Study-rate variation			
Combining study and work			

The working definitions of operational and conditional flexibility can be used to determine the flexibility of an educational programme in a direct, objective way by systematically scoring the data related to a specific programme. In contrast with these 'objective' definitions of flexibility, we consider the judgment of a programme coordinator generally perceiving the flexibility of the own programme as a 'subjective' definition of flexibility, which also can be expressed in a score.

Method

A main question to be answered in this study is whether educational programmes, considering the characteristics of educational systems, have a format that influences flexibility. In an explorative approach, a survey was used to get a clear picture of educational programmes, their current flexibility and the available conditions to improve their flexibility. The constructs of flexibility were used to develop a questionnaire covering the data required to determine the format of educational programmes (see Table 1). The working definitions of flexibility are used to measure the flexibility of the educational programmes. These measured 'objective' flexibility scores for the programmes are compared with the estimated 'subjective' scores of the respondents for the perceived flexibility of their programmes, in order to find out how objective and subjective scores are related. We expect that the operational-flexibility scores, representing the actual flexibility of a certain programme implementation, will correlate positively with the subjective flexibility scores of the respondents for their programmes. The conditional-flexibility scores will represent the available conditions for the flexibility of educational programmes. A discrepancy between conditional and operational flexibility scores will indicate to which extent the flexibility can be improved. Relating the conditional flexibility scores to the subjective flexibility scores will make clear whether the latter scores may reflect the conditions for flexibility as perceived by the respondents.

Sample
The BA field in HPE institutes, was selected for this study, because it is a large and relative homogeneous sector, which can be considered as representative for the mainstream of educational programmes in higher education in The Netherlands. The non-academic HPE institutes generally offer a wide range of programmes in the BA field with different content orientations and programme modes. The official list of programmes in HPE for the year 1999-2000 (Informatie Beheer Groep, 1998) mentions 31 government-financed HPE institutes, each offering a selection out of 31 different degree programmes in BA. Taking into consideration the modes (full time, part time and dual) of these programmes, 333 programmes in total were counted, together serving about 25% of the total HPE-student population in The Netherlands (CBS, 1999). The survey consisted of a sample of 292 programmes offered by twenty-two institutes, each with four or more different degree programmes and including the basic programmes 'business economics' and 'commercial economics'. To improve the representativeness of the programmes for purpose of our study 9 HPE institutes with a small number of only specialized programmes in an atypic professional field (e.g., hotel management, facility management) have been excluded from the survey sample.

Questionnaire
A questionnaire was developed to get information and data for the topics related to the constructs: Curriculum, Activities, Facilities and Environment (see Table 1). In addition, the respondents are asked to estimate the flexibility of the programme in a subjective flexibility score and to mention important factors for improving the flexibility.

The questionnaire was designed for a single degree programme (e.g., business economics) in a specific mode (full time, part time or dual) as it was formally offered by a specific educational institute. In order to restrict the response time to less than half an hour, the questions were sequenced and formatted to be answered quickly with yes or no, by ticking alternatives, or by giving short answers. Where possible, questions have been made conditionally (e.g., 'If Yes, then ...). A few open or partly open questions completed the questionnaire. For each programme a questionnaire form was sent to the institutes, to be answered by the programme coordinator or a well informed colleague, followed by one reminder after two weeks.

Data
The survey data were analyzed uncategorized, and categorized by degree programme, programme mode and institute. The general label 'programme' refers to any programme, combining a specific degree programme, programme mode and institute. For a further analysis, data are categorized by degree programme, programme mode and institute. 'Degree programme' refers to programmes categorized by professional field, e.g., Business economics or Accounting. 'Programme mode' refers to a categorization in full-time, part-time and dual programmes (comparable to 'sandwich courses' in the UK). Data categorized 'by institute' refer to the programmes of one institute. For reasons of anonymity, data categorized by institute are presented in clusters. In the results categorized for degree programmes we have omitted degree programmes with less than four responses, leading to a final list of ten degree programmes (see Table 2 for an overview).
Data are normally presented uncategorized (for all programmes), and - where considered relevant - categorized for degree programmes, programme modes or institutes. Percentages are presented in round figures and refer to all programmes or predefined categories of programmes, unless indicated otherwise. The number of relevant responses (for all programmes n = 128) is only mentioned in case of missing responses and other deviations in the number of responses (e.g., 'if-then' questions).

Results

The survey results of 128 completed questionnaires (response: 44%) are presented in three subsections. The first subsection: 'Programme data', presents a selection of data on topics related to the flexibility constructs. The second subsection: 'Operational format', gives a summarizing description of the operational format of programmes. Finally, the subjective and objective flexibility scores are presented in the third subsection: 'Flexibility scores'.

Programme data
In this subsection, the survey results regarding relevant topics with respect to flexibility are presented in order to characterize the educational programmes in the BA field in HPE in The Netherlands. The data are presented with reference to the flexibility constructs: Curriculum, Activities, Facilities and Environment.

Curriculum: "How are programmes structured and how can students enroll and participate in a programme?"

Structure. In practically all curricula the study period is formally defined (98%), in most cases (86%) a study period of four years. Programmes are structured in study years (91%) and in study phases (96%), which are often connected to study years (82%).

Study load. The study load of a programme is formally fixed (99%), and in most cases (85%) formally defined at 6720 hours (four years of 42 weeks, each of 40 hours). Formally the study load is spread equally over the study periods (98%). Study-period and study-load definitions are founded in national educational laws and regulations.

Study units. For 98% of the programmes the curriculum was built from a number of study units (modules) which are defined with respect to their place in the study year or study phase (98%), content (95%), study load (95%), study result (95%), unit sequence (93%) and number of (teacher) contact hours (91%).

Target group and enrollment. HPE in The Netherlands is organized in specific degree programmes, which are normally clustered in faculties and institutes. A student has to choose a certain degree programme and - where available - a specific programme mode that fits his or her circumstances. Given that choice, students are normally expected to enroll for a complete degree programme. Of the programmes, 66% are not restricted to a specific target group and require general entry conditions for admission to HPE. The other programmes include, for instance, shortened study routes for students with collective exemptions for qualifications acquired in preceding content-related programmes.

Starting and finishing. In 89% of the programmes, students can *not* start their study at any moment related to their individual needs. For these programmes (n = 114) opportunities to start a programme are normally restricted to once (35%) or twice (45%) in a year. Completing a programme formally (assessment and certification) is for 78% of the programmes normally possible at up to four pre-planned opportunities in a year.

Differentiation. Programmes are said to anticipate differences between students (63%), offer choices out of study units (73%) and / or specializations (57%). About 70% of all programmes have a common programme part of 70% or more study load (in study hours). For about 46% of the programmes that common part was 90% study load or more, leaving 10% or less to vary for individuals or groups of students. Programmes with specializations (n = 73) have a mean common part of 77% study load, compared to a mean study load of 84% for programmes without specializations.

Grouping. Permanent grouping is a way to organize participation in educational programmes. In 89% of all programmes, groups are formed for a period of one year or longer. For 79% of the programmes these groups are characterized as year-class

groups. Grouping is not based on perceived differences between students (67%) and does not aim at solving specific organizational problems (65%).

Participation, assessment and exemptions. The freedom of students to participate in their degree programmes varies. In 56% of the programmes students are not free to decide which of the planned study units they do or do not want to take. To complete a study unit it is not necessary to participate in the related activities (e.g., by attending lessons): In 73% of the programmes it is sufficient to assess a study unit successfully. Students are allowed to take study units outside their programme (63%) and to change the order of study units (44%) as far as this is possible in the actual planning. Assessment is based on study units. Students are allowed to reassess study units which they did not pass at the first occasion (97%). Most programmes (96%) allow individual students to skip study units by getting exemptions, e.g. for comparable study units acquired in other study programmes.

Activities: "How are students expected to spend study time in their programme?"
Study year. In a study year normally a period of 28 to 42 weeks (average about 37 weeks) is available for normal (scheduled) educational activities. Institutes are not closed at all (11%) or completely closed up to 8 weeks (86%).

Study periods. Considered operationally, almost all programmes (99%) are structured in a number of fixed study periods in a year. Combining the programmes organized in 4 or more blocks of about 10 weeks (52%) and quarters (19%), suggests a strong preference for a division of a study year in four study periods of an equal size. Each study period is normally structured in lesson periods of 6 to 8 weeks and an examination period of 1 to 3 weeks.

Lessons. Students are expected to spend a mean of 38% of their study time (about 15 hours and 20 minutes in a 40-hours study week) in contact situations (lessons, teacher support, self supportive study groups, etc.). Only a part of that time is spent in a mean of 7 (scheduled) lessons of about 45 to 50 minutes, varying slightly for programme modes (full time: 8 lessons, part time: 5, dual: 8), specific degree programmes (5 to 9 lessons) and for specific institutes (5 to 7).

Schedule. In 98% of the programmes a schedule or timetable is used to plan a programme. Many programmes (74%) use a periodical week schedule. Schedules are based on a specific time unit (98%), use units of 45 or 50 minutes (80%), up to a number of 8 to 10 units in a normal working day (50%). Schedules are used normally to plan the contact hours of the teachers (91%), teacher-guided meetings of students (84%) and the available accommodation (91%).

Content. Considering the content orientation of programmes, students spend 42% of their study time (16 hr 34 min weekly) in discipline-focused (in contrast to theory-integrated and practice-oriented) activities, varying slightly for part-time (37%) and

dual programmes (40%). Institutes vary considerably more (18% to 68% of the study time).

Location. Students spend on average 37% (14 hr 50 min) of their study time at the institute, 39% (15 hr 24 min) at home and 24% (9 hr 30 min) in other study-related situations (field settings, apprenticeship, etc.).

Facilities: "Which facilities are available for the support of the students in their programme activities?"

Accommodation. The building of the educational institute is a main facility which is used commonly by many students and programmes. Institutes are normally open on all working days (98%), in the evenings (95%) and sometimes on Saturdays (24%). A weekly day starts at 8:00 a.m. or earlier (91%) and ends at 10:00 p.m. or later (79%), resulting in a mean of almost 14 opening hours each day and about 70 hours in a week (without weekend hours).

Study places. At the institute, students have study places available for individual use. They are expected to use them normally for a mean time of 8 hr 36 min in a week, varying for full-time (10 hr 48 min), part-time (3 hr 06 min) and dual programmes (11 hr 30 min). Teachers normally have an office (72%) and desk (71%), which have to be shared sometimes with others. These figures differ considerably for specific institutes.

Library. For all programmes (99%) a library is available, which is considered indispensable to support the programme (63%) and offers a substantial amount of the individual study places and ICT-facilities (88%). Library service is available for a mean of almost 50 hours per week.

Study materials. In addition to the study books that students normally buy, they use teacher-developed study materials (85%) and (audiovisual and interactive) electronic study materials (63%). The use of educational or instructional software (54%) differs for programme modes (full time: 57%, part time: 46%, dual: 40%).

ICT facilities and infrastructure. In almost all the programmes (96%) students and teachers are expected to have access to ICT facilities. ICT is considered essential for the programme (84%). The use of standard software is widespread (98%), followed by the use of the Internet (84%), student monitoring systems (83%) and - at a much larger distance - the use of specific educational or instructional software (54%).
A substantial amount of the individual study places at the institute is equipped with PC's. Practically all institutes have a computer network (99%) and a web site (98%) available. At home, students and teachers can connect to the network of the institute (66%). But for only 31% of the programmes students and teachers are expected to have a PC available at home (full time: 26%, part time: 44%, dual: 18%).

Teacher capacity. A main resource for programmes is teacher capacity. Using programme-related student numbers and teacher capacities, a teacher-students ratio was calculated for each programme, which resulted in a general mean of 33.4 students for 1 fte (full-time equivalent) teacher capacity (*SD* = 36.6, *n* = 113). Categorized for programme modes, full-time programmes scored 31.5 (*SD* = 42.8, *n* = 61), part-time programmes scored 40.4 (*SD* = 30.2, *n* = 37) and dual programmes scored 24.3 students (*SD* = 17.7, *n* = 15). Categorized for degree programmes, Commercial economics (*M* = 53.6, *SD* = 82.3, *n* = 16) and Management, commerce and law (*M* = 38.8, *SD* = 22.9, *n* = 12) show a relatively high ratio. Commerce and languages (*M* = 18.9, *SD* = 10.1, *n* = 4) and Information services management (*M* = 21.0, *SD* = 10.5, *n* = 5) show a low ratio. Clustering programmes for institutes (the data represent 22 institutes in total) shows even more striking differences: ranging from 10-20 students (three institutes with 14 programmes in total) to 40-50 students (four institutes, 24 programmes), and a single institute (with five programmes) has a ratio of one teacher fte for 100-110 students.

Environment: "How does a programme fit in its environment?"
A programme's fit in the environment has several aspects, for instance, recognizing and accounting for the external needs of individual students and allowing them to combine study and work in a convenient way. Due to our focus on single programmes, the relations and cooperation between programmes are also relevant here.

Size. Student and teacher numbers are indicators for the size of an institute. The mean total number of students in a programme is 305 (*SD* = 298, *n* = 127), varying considerably across institutes, degree programmes and programme modes. Cumulative frequencies show that 49% of the programmes have a total number of 200 or less students. Comparing programme modes, part-time programmes have a relatively low mean total number of 139 students (*SD* = 140, *n* = 41) compared to 421 for full-time (*SD* = 305, *n* = 71) and 209 for dual programmes (*SD* = 350, *n* = 15). Degree programmes vary from a high mean of 647 students (*SD* = 542, *n* = 9) for Communication, to a low 107 students (*SD* = 84, *n* = 5) for Information services management. The mean number of students in programmes varies also considerably for institutes: from a mean of 88 (*SD* = 53, *n* = 2) up to 549 (*SD* = 431, *n* = 7).
The mean number of teachers for a programme is 25, representing a mean teacher capacity of 12.2 fte. Programme modes differ considerably in teacher numbers and capacity. Teacher jobs in part-time programmes generally are of a small size.

Organization and cooperation. Within an institute, programmes are involved in several forms of cooperation, e.g., sharing teacher capacity (79%), using parts of other programmes (58 %) and sharing programme parts with other departments (53%). In 70% of the programmes there is cooperation with non-educational organizations, e.g., for apprenticeships. Data categorized for institutes show that cooperation between departments (together responsible for a programme or taking care of more than one programme) varies strongly. Of the departments responsible for part-time programmes (*n* = 41), 50% is *not* involved in cooperation with non-educational external

organizations, compared to 18% (n = 72) for full-time and 21% (n = 14) for dual programmes. Of the departments responsible for dual programmes (n = 14), 93% are involved in personnel-capacity cooperation compared to 81% for full-time (n = 72) and 73% for part-time programmes (n = 41).

Educational approach. Educational concepts reflect how students are conceived and indicate how a programme intends to meet the expectations of the environment. Many respondents (84%) mentioned innovative and other concepts or principles that have been applied in the programme and that characterize the educational approach, e.g., project approach (89), competency-based learning (44), problem-based learning (40), action learning (27), tele learning (19) and thematic education (17). Other data indicate that 38% of the programmes apply (conventional) distance education, ICT supported (tele) learning or a combination of both approaches.

Combining study and work. Students may need to combine study and work. Dual and part-time programmes have been designed normally to meet that need. Respondents indicate that in 38% of the full-time programmes it is also possible to combine study and work in a structural way. In programmes where the respondents indicated that it is possible to combine study and work activities (68% of the full-time, n = 32); 44% of the part-time, n = 39; 93% of the dual programmes, n = 14), it is not the individual student's work setting but the common study programme that determines how to combine study and work. They say that individual students can combine their study with an already given work situation in 47% of these full-time, 56% of the part-time and 86% of the dual programmes. For 54% of all 128 programmes it is not normal that individual students can take up their study activities immediately after a period of other activities, e.g., a temporary job period.

Operational format

The survey data focusing on the operational aspects of flexibility, were used to generate a comprehensive description of the format of the educational programmes. This description comprises the common characteristics and some typical characteristics for the different programme modes, degree programmes and institutes.

Common characteristics. A programme in the BA field of HPE formally takes four years of study and has a fixed total study load that is equally spread over these years. The programmes are structured in predefined study units (modules). Assessment is based on study units and takes place by testing knowledge and skills, assessing products and checking assignments. Students failing a test get a second chance. Exemptions are possible. Most programmes are defined for a general target group and offer restricted opportunities for differentiation. Many programmes allow to combine study and work, but most programmes determine (and restrict) the possibilities.
Students can normally enroll once or twice in a year. They are organized in year groups for participation in a specific degree programme. There is a certain freedom to do the study units in their programme and they can select units of other programmes. Many year programmes are organized in four time-blocks of about ten weeks,

composed of lesson and examination weeks. Students spend a substantial part of their study time at the institute in interaction with other students and teachers, partly in lessons. Normally a schedule is used to plan all lessons and other teacher-coached meetings. Many study activities are discipline-focused, i.e., concentrated on the study of just one specific content discipline.
Most programmes are taught at a single location, which is open on Monday to Friday from 8 a.m. to 10 p.m. There is a library and students have study places available for individual study, most of them equipped with a PC, which is connected in a network of the institute. Many teachers have their own office, with a desk and a PC available at the institute. All the institutes have a web site and offer Internet access. For most programmes, the use of ICT, standard software and Internet facilities is required and obvious. But for only one third of the programmes, students (and teachers) are expected to have a computer at home, and about a same part has tele learning or distance-education facilities. Programmes involve on the average about 300 students and 25 teachers. The effective mean teacher-students rate for programmes is 1 fte teacher capacity for 33.4 students.

Differing characteristics. Although the preceding general description of the format fits all programmes on most aspects, categorized for programme modes, degree programmes and institutes there are also some typical differences. Part-time programmes have a lower number of lessons which are scheduled at evenings, less time to spend at the institute and more time to study at home, compared to full-time and dual programmes. They have fewer students but relatively high numbers of new students. The available teacher capacity and the involvement in external cooperation are lower. Part-time programmes determine less than other modes how to combine study and work. Distance education, telelearning and a PC at home are more common than in other programme modes. Full-time programmes are the main programme mode. Most programmes are full time and have large student numbers. Students spend relatively more time in contact activities and lessons. Distance education and tele learning play a minor role, instructional software has a more important role than in other programme modes. Dual programmes are clearly a new developing programme mode, which is not yet widespread. Within institutes there is much cooperation with other programmes and departments. Programmes, which may have started not too long ago, are often still incomplete and have, as a consequence, low total student numbers compared to relatively high numbers of new students. Dual programmes seem better equipped than other modes, having small student groups, high teacher capacities and better facilities for teachers (more frequently an own office). Somewhat contrarily, the use of ICT is on several aspects (PC at the student's home, instructional software) less developed than in the other modes. The study periods in the alternating periods of study and work, the main operational characteristic of dual programmes, seem to have many operational characteristics in common with full-time programmes, e.g., the number of lessons.
Main differences for degree programmes are the numbers of programmes that are available nationally (see Table 2) and the total numbers of participating students. Programme modes are not spread equally across all degree programmes. Other differences

regard the cooperation with other programmes, the relative time spent at different study locations and the use of ICT facilities. Institutes mainly differ on the total number of students, mean number of students in programmes, and mean teacher- students rate. Other differences regard the cooperation between programmes and departments, time spent in lessons, discipline orientation and teacher facilities.

Flexibility scores
The respondents estimated the flexibility of their programmes using a rating scale (score from 0 = not flexible at all, up to 10 = very flexible) and they mentioned factors of importance for improving the flexibility of programmes in general. In addition to these subjective flexibility scores, we used data from the questionnaires to calculate objective flexibility scores based on our working definitions and constructs.

Subjective flexibility scores. The estimated flexibility scores for the programmes of the respondents resulted in a mean subjective flexibility score of 6.2 (*SD* = 2.0, *n* = 107). These flexibility scores are practically equal for the different programme modes. Much more differences show the data for degree programmes and institutes. Table 2 gives the mean flexibility scores categorized for degree programmes and programme modes. Categorized for institutes, 2 institutes have mean scores between 4 and 5 (*n* = 13), 2 institutes between 5 and 6 (*n* = 15), 12 institutes between 6 and 7 (*n* = 59), and 6 institutes between 7 and 8 (*n* = 20).

Objective flexibility scores. For each programme, objective scores for the flexibility constructs and for operational and conditional flexibility have been calculated. To calculate a construct score, a set of 10 related questions has been selected from our questionnaire. Each answer that contributed positively to the flexibility construct, added 1 (one) to the construct score, up to a maximum score of 10. The operational flexibility score of a programme was calculated as the mean of the Curriculum and Activities construct scores, the conditional flexibility score as the mean of the Facilities and Environment scores. In addition to these scores, a 'discrepancy' score has been calculated: The conditional flexibility score minus the operational flexibility score.
The operational flexibility scores, supposed to express the actual flexibility of programmes, are generally low (*M* = 3.0, *SD* = 1.1) and do not show much variation. Scores do not differ much for degree programmes and are practically equal when categorized for programme modes. Categorized for institutes they differ more: The mean scores range from a lowest score of 2.0 to a highest score of 4.3 for specific institutes. Table 2 gives the scores for degree programmes and programme modes.

Table 2. Mean flexibility scores for degree programmes and programme modes

Mean flexibility scores		Objective (*n* = 128)							Subjective	
		Curriculum	Activities	Facilities	Environment	Operational flexibility	Conditional flexibility	Discrepancy	Flexibility score	*n*
Degree programmes (*n*)										
Accounting (12)	*M*	2.3	2.6	6.0	5.6	2.4	5.8	3.4	3.7	12
Accountancy	*SD*	1.6	1.0	2.0	2.4	0.8	2.0	2.3	2.6	
Business economics (26)	*M*	2.8	3.1	6.1	5.9	2.9	6.0	3.1	5.9	26
Bedrijfseconomie	*SD*	1.7	1.3	2.0	1.8	1.1	1.6	1.8	2.0	
Office automation (17)	*M*	3.2	2.9	6.2	6.4	3.0	6.3	3.2	7.5	17
Bedrijfskundige informatica	*SD*	1.5	1.4	1.6	2.3	1.1	1.6	1.7	0.8	
Commercial economics (17)	*M*	3.0	3.8	6.8	6.2	3.4	6.5	3.1	5.8	14
Commerciële economie	*SD*	1.3	1.3	1.4	1.6	1.1	1.1	1.7	2.2	
Communication (9)	*M*	3.0	3.0	5.8	6.1	3.0	5.9	2.9	7.1	9
Communicatie	*SD*	1.1	0.9	1.0	1.6	0.6	0.9	1.0	0.5	
Commerce and languages (4)	*M*	3.5	3.3	5.5	5.5	3.4	5.5	2.1	7.0	2
Economisch-linguïstisch	*SD*	1.0	0.5	0.6	1.3	0.6	0.7	0.5	0.0	
Taxation (4)	*M*	3.5	1.5	6.8	6.8	2.5	6.8	4.3	7.0	2
Fiscale economie	*SD*	2.5	1.9	1.0	1.9	2.0	1.0	1.3	1.4	
Information services and management (5)	*M*	2.0	2.8	6.2	5.2	2.4	5.7	3.3	6.2	5
Informatiedienstverlening en management	*SD*	1.6	1.6	0.4	0.8	1.5	0.3	1.7	1.3	
Distribution (4)	*M*	2.8	3.5	6.8	6.0	3.1	6.4	3.3	7.0	2
Logistiek	*SD*	1.0	0.6	1.3	0.8	0.6	0.5	1.0	1.4	
Management, commerce & law (13)	*M*	2.9	3.3	4.8	5.8	3.0	5.3	2.3	6.4	10
Management, economie en recht	*SD*	1.7	1.3	2.1	1.6	1.4	1.5	2.4	1.5	
Programme modes (*n*)										
Full time (72)	*M*	2.9	3.0	6.1	5.9	2.9	6.0	3.1	6.2	61
	SD	1.4	1.2	1.4	1.7	0.9	1.2	1.4	1.6	
Part time (41)	*M*	3.0	3.3	6.1	6.0	3.1	6.0	2.9	6.1	32
	SD	1.8	1.5	2.0	2.0	1.3	1.7	2.1	2.6	
Dual (15)	*M*	2.8	3.2	6.1	6.0	3.0	6.0	3.0	6.2	14
	SD	1.8	1.5	2.2	1.7	1.2	1.5	2.3	2.3	
All programmes										
	M	2.9	3.1	6.1	6.0	3.0	6.0	3.0	6.2	107
	SD	1.6	1.3	1.7	1.8	1.1	1.4	1.8	2.0	

Note. The degree programme names presented in *italics* are the original Dutch names.

Using Pearson 2-tailed correlation, a significant positive correlation of $r = 0.343$ ($p < 0.01$) has been established for the subjective flexibility scores and the objective, operational flexibility scores. For both underlying Curriculum and Activities construct scores the correlations with the subjective flexibility scores are also significant, respectively $r = 0.308$ ($p < 0.01$) and $r = 0.219$ ($p < 0.05$). For the Environment and the Facilities constructs, which form the basis of our conditional flexibility score, the correlations are respectively low ($r = 0.014$) and negative ($r = - 0.184$). There is a significant negative correlation of $r = - 0.321$ ($p < 0.01$) between the subjective flexibility scores and the discrepancy scores (conditional minus operational flexibility score).

Factors to improve flexibility. The respondents were asked to mention the factors they consider of importance to improve flexibility. Of the respondents 71% mention one or more factors. The factors that have been mentioned most frequently, are reported here, with their respective frequencies.
With respect to the Curriculum construct, 17 reactions specify more general needs for an increase in flexibility: more individualized study programmes, more programme routes and variations, more demand-oriented programmes. For the degree programme Accounting the reactions (8) are very concrete and consistent: Drop the (centralized) national programme definitions and exams. For the Activities construct, many reactions (24) refer to technical and practical improvements in organization and planning: free timing and placing, free starting and stopping, free sequencing, better lesson schedules, drop grouping in classes, offer study units repeatedly, change the organization. Other reactions (22) focus specifically at the use of modules: modular planning, more optional modules, programming in exchangeable blocks. References to the Facilities construct focus at the availability of more and better ICT facilities (11) or specifically to the introduction of telelearning (8). More general reactions refer to the improvement of accommodation, facilities and infrastructure (9). Regarding the Environment construct, 14 respondents mention the introduction and implementation of new educational concepts (e.g., competence-based learning, action learning and thematic approach). The quality, availability and flexibility of teachers is considered as another important factor, which has been associated here with restricting legal regulations (10). Increasing student numbers and more money for institutes and students are mentioned by respectively 9 and 5 respondents.

Discussion

The results of our survey show that HPE programmes in BA in The Netherlands have many operational characteristics in common. The programmes are formally structured at different levels by fixed time formats. The possibilities to start, stop and interrupt programme participation are restricted. The curricula consist of study modules that determine many operational aspects. The planning of teaching and learning activities is centralized and student participation is organized in programme-related year groups. These operational characteristics are found in many educational programmes. As expected, they constitute a rather rigidly organized standard format that seems to restrict the flexibility of these programmes to a large extent.
On the positive side, educational programmes in this format show possibilities for variation and choice. Programme differentiations and specializations offer choices out of study modules. Students are allowed to participate selectively in programme activities. They can get exemptions and may use modules from other programmes. Dual and part-time programme modes offer dedicated time patterns to combine study and work. And within any programme, students have a substantial amount of study time available in which they can vary their study activities according to individual needs.
In the context of these results and under the assumption that programmes in BA are representative for programmes in higher education, it can be concluded that government-financed higher-education institutes in The Netherlands generally offer their students a format of collectively organized programmes with a strong supply character and restricted possibilities for individual variation. It should be noted that for programmes in more practice-oriented and facility-dependent professional and academic fields, - a relatively small part of all programmes in higher education -, this conclusion may not be true to the same extent.
To find out how flexible educational programmes are, their flexibility has been measured in objective scores, leading to a mean objective score for operational flexibility of 3.0 out of a maximum score of 10. To compare these scores, the respondents were asked to rate the flexibility of their programmes on a 10-points scale. These estimated scores resulted in a mean subjective flexibility score of 6.2, probably indicating that the flexibility of their programmes is not judged too bad, but also that there is substantial room for improvement. Despite a significant positive correlation for operational and subjective flexibility, the much lower mean score for operational flexibility asks for an explanation. When both scores intend to represent the actual flexibility of educational programmes, there might be a differing focus on flexibility. The objective score intends to focus on the operational aspect, referring to a standard format that formally does not leave much room for variations, e.g., to meet the needs of individual students. The subjective score may express a more general notion of flexibility, referring to the overall characteristics of the educational system with respect to flexibility. The relatively high subjective scores may indicate that the small scale of many programmes allows to compensate for a lack of (operational) flexibility by creating ad hoc solutions and personal arrangements in case of individual planning problems of students.
Quite interesting is that subjective as well as operational flexibility scores are almost equal for the different programme modes. Part-time and dual programmes, which are

designed to combine study and work in a convenient way, did not have higher flexibility scores compared to full-time programmes. This may indicate that the operational differences which are found between the programme modes, do not influence the flexibility of the programmes in a substantial way. On the contrary, the flexibility scores categorized for degree programmes and institutes demonstrate that the flexibility scores can vary substantially. These findings may generally support the idea that the common standard format that we have found across the programme modes can be of crucial importance for the flexibility of educational programmes. We need further research to find out more specifically which factors are included here and how they are related to flexibility. Special attention is needed then for the organizational aspects, which have been somewhat underexposed, due to the decision to take a degree programme as the unit of analysis. Categorizing for the size of institutes may reduce the large dispersion, which some of our data show now.

Our notion that a common standard format may play a role in determining flexibility, is in line with findings of Van Meel (1992) and Collis, Vingerhoets and Moonen (1997). However, the expectation of Van Meel (1997) that modularization and part-time programming will contribute to an increase of flexibility is *not* supported by our findings. Although the programmes in our study are almost completely modularized, they still score low on flexibility. In addition, part-time (and dual) programmes did not score better on flexibility than full-time programmes. Collis, Vingerhoets and Moonen (1997) found that the use of telematics-supported learning events in the EU Telescopia project did not lead to more learner flexibility. That is supported by our finding that the availability of new ICT-means did not seem to contribute substantially to flexibility. Their explanation that "all courses were still courses" justifies our conclusion that the standard educational format can be considered as an obstacle for increased flexibility. They conclude that conceptual changes are required and will have significant organizational impact on course delivery institutions (Collis et al., 1997, pp. 210-211).

Our findings also support the main idea that a focus on the operational aspect of educational programmes may be fruitful to improve flexibility in education. When, for instance, the number of classroom-based lessons is reduced to a mean of 7 weekly lessons, the widespread use of periodic lessons scheduling seems no longer necessary. Considering the huge impact of this and other typical operational structures and processes in education, we find it astonishing to see how persistent they are and how little attention they get. It gives rise to the idea that future research should be directed to the operational format of educational programmes. A combined approach of operations management (Krajewski & Ritzman, 1996) and educational technology may offer useful approaches to analyze educational systems and to develop solutions in order to improve the flexibility. Their respective contributions can be expected to solve the problem, how at the one side the available resources (personnel and material) can be used to improve the flexibility of educational processes, and at the other side the effectivity and efficiency of these processes can be maintained or increased. Solutions have to be found in developing new educational formats that can be implemented in educational institutes within the conditions which are or must become available to find an acceptable balance of both aspects.

We may conclude by establishing that higher education is changing, influenced at the one side by new educational concepts and approaches (e.g., lifelong learning, self-managed student learning, practice orientation and integration) and at the other side by an expanding context of increased participation and mobility within Europe and a growing worldwide competitiveness. There is a need to consider the possible consequences of these changes for the organization of educational institutes and the related teaching and learning processes. Before we come to a common educational format in the European Union it is necessary to consider critically whether the current operational formats which can be found in many educational systems in Europe and elsewhere are still effective and efficient. Developing alternatives could be a crucial challenge, not just to improve the flexibility of higher education but as a means to take away serious obstacles for structural changes and innovations that are needed to develop an attractive and competitive higher education system in Europe.

Chapter 3. An operations-management approach of educational programmes[1]

In a recent survey, Schellekens, Paas and Van Merriënboer (2003) concluded that the flexibility of educational programmes in Dutch HPE needs to be increased. The results indicated that changing the operational structures and processes in organizing educational programmes can increase the flexibility. In the current study, concepts and tools from the field of operations management are used to analyze the operational design characteristics of educational institutes, which are considered as service organizations. In order to customize educational programmes to the needs of the students, a process-focused strategy is applied. In a case study, discrete-event simulation was used as a tool for a simulation experiment, in which a new educational-system design with a more favorable proportion of group-based and individually planned work was compared to the actual system. Consistent with the hypothesis, the new design was more flexible as indicated by a shorter study duration and waiting time for the students. As expected, simulation appeared a promising tool to study the effects of curriculum change on the flexibility of educational programmes.

In a recent survey, Schellekens, Paas and Van Merriënboer (2003) studied the flexibility of BA programmes in HPE in The Netherlands[2]. They argued, that there is a strong need to improve the flexibility of educational programmes in higher education. Among other reasons, employers need more employees with higher levels of education, students need to combine work and study in a more convenient way, the European Union aims at increasing the mobility of students, and the introduction of lifelong learning will attract new categories of students. As a consequence, educational programmes must accommodate students with increasingly different characteristics, such as prior knowledge, study capabilities, personal circumstances, nationality and work experience. Accordingly, flexibility was defined as "... the extent to which students can get an educational programme which fits their educational needs within the normal conditions of an educational institute" (Schellekens et al., 2003, p. 282). The results of the survey study indicated, that educational programmes in HPE have a typical operational format, which is not very flexible. It was proposed to increase the flexibility of educational programmes by changing their operational format.
In this article, concepts and tools from the field of operations management are applied to study educational systems in order to increase the flexibility of educational

---

[1] Based on: Schellekens, A., Paas, F., Verbraeck, A., & Van Merriënboer, J. J. G. (2003). *Flexible programmes in higher professional education: An operations management approach.* Manuscript submitted for publication.

[2] In The Netherlands, HPE institutes offer nonacademic programmes for higher education. Kouwenaar, K. and Stannard, J. (Eds.) (1988), and Haug, Kirstein and Knudsen (1999) describe the higher-education system of The Netherlands.

programmes. First, concepts from the field of operations management are used to position educational systems as an object of study. Second, an operations management approach is applied, using simulation as a tool to study complex system changes in order to increase the flexibility of educational programmes. Third, a case study is described in which the effect of a curriculum change on the flexibility of educational programmes is studied in a simulation experiment. Fourth, the results of the experiment and the validation of the simulation are presented. Fifth, the results are discussed in the light of the question, how operations management can contribute to increasing the flexibility in higher education.

An operations-management positioning of HPE institutes

Operations management studies real world systems like factories, restaurants and call centers, in order to improve their performance. Addressing the direction and control of the processes that transform inputs into finished goods and services, operations management offers concepts, approaches and tools to support making decisions for strategic management, operational design, and process management (Krajewski & Ritzman, 1996; Starr, 1989; Waters, 1996). Systems are considered with respect to factors as time, cost, quality, and also flexibility. Two main types of flexibility are recognized: customization and volume flexibility. Customization is the ability to accommodate the unique needs of each customer and to change product or service designs. Volume flexibility is the ability to quickly adjust the rate of production to handle large fluctuations in demand (Krajewski & Ritzman, 1996). In this context, following the earlier definition, flexibility can be considered as a factor to improve educational-system performance, where flexibility primarily is interpreted as 'customizing educational services to the needs of students'.
Krajewski and Ritzman (1996) present a framework for the positioning of organizations as an object of study in operations management, using concepts at the levels of strategic management, operational design and process management (see Table 1). At each of these levels the relevant concepts are explained and used for an analysis to position higher-education institutes, based on the operational characteristics of educational programmes as found in the survey in HPE institutes in The Netherlands (Schellekens et al., 2003).
At the level of strategic management, two main categories of organizations, can be distinguished: manufacturing and service organizations, (Chase & Aquilano, 1989). Educational institutes, which support the learning of students, can be considered as service organizations, like - for instance - hospitals and banks. Generally, their service is 'education', aiming at the long term result of an increased competence of students. Ideally, students are primarily responsible for the results of their own study activities and the related competence-development process, which must clearly be distinguished from the educational support process. Learning and development are processes of individual students, supported by the activities of teachers and other arrangements, which are offered as services by educational institutes. To reach satisfying educational results, the educational support process must fit the learning and development processes of the individual students.

Table 1. Conceptual framework for positioning organizations

Strategic management	
Manufacturing organizations	*Service organizations*
Produce durable, physical products which can be stored. Production processes have long response times and low customer involvement.	Offer 'services': intangible, not storable 'products' which can not be produced in advance. Service processes have short response times and high customer involvement.
Operational design	
Product-focused strategy	*Process-focused strategy*
The operations are organized separately for each product or service in one line of operations, without competition for resources (for instance, work force, facilities, and equipment). This strategy fits a profile of a few standard products or services, each produced or offered in large quantities, matched with value- consistent quality and low costs. Traditionally, 'mass production' is the adequate approach. Typical examples are automobile-assembly plants and fast-food restaurants.	The operations are commonly organized in coherent units, taking part selectively in the process needed for different products or services, each following dedicated patterns and competing for common resources. This strategy fits a profile of highly customized products or services and low volumes, matched with high performance design quality, high customization degree and volume flexibility. The adequate approach is 'mass customization', requiring a flexible operational strategy providing products and services with a high degree of adaptation to the needs of clients. Typical examples are job shops and general hospitals.
Process management	
Process choice refers to the operational processes which are applied, for instance, line processing, batch processing, and project approach.	
Vertical integration refers to the degree an organization takes care of its own operational processes, instead of buying or hiring necessary services or products elsewhere. Vertical integration is attractive when volumes are high and the related operational processes are efficient and low cost.	
Resource flexibility concerns the degree of flexibility to deploy people, facilities and equipment in operational processes.	
Customer involvement is the extent to which customers are involved in the operational process.	
Capital intensity is the relative amount of capital needed for equipment, compared to the costs for skilled labor, representing the degree of automation in a production or service process.	

Note. Adapted from Krajewski and Ritzman (1996).

The level of operational design concerns how to organize the operations system, where a product-focused and a process-focused strategy can be considered as extremes on a continuum (Krajewski & Ritzman, 1996; Waters, 1996). If educational institutes are considered as service organizations with students as clients with diverging needs, capabilities and aims, a process-focused strategy could be expected. However, Schellekens et al. (2003) found that most HPE institutes are organized according to a product

focus. The output of education is defined in terms of a restricted number of standard professional profiles. For each profile, the educational support is organized in educational programmes, which consist of dedicated and practically linear organized standard treatments. Obviously, the operational design of the educational support process is standardized to such an extent, that students with different study conditions (e.g., full-time and part-time students) require separately organized programme variants, which aim at an almost identical range of professional profiles. If it is assumed that educational support processes must accommodate the learning processes of the individual students, which would require a process-focused strategy, there is a substantial discrepancy with the actual product-focused organization of educational programmes.
The process-management level regards the selection of inputs, operations, work flow and methods for the operational-process design. Decisions concern process choice, vertical integration, resource flexibility, customer involvement and capital intensity (Chase & Aquilano, 1989; Krajewski & Ritzman, 1996; Waters, 1996). In education, process choice shows a combined approach of line and batch processing, which can be recognized in the widespread convention of permanent programme-based grouping. Education is organized in year groups, which have their own programme and variant. Each programme consists of a fixed number and sequence of predefined operations. Scheduling intertwines all of these batched linear processes, requiring strictly standardized formats of classes, lessons, study periods and study years. In addition, the admission and participation of students is carefully defined and restricted by selection and passing regulations. As far as students can stick perfectly to their pre-planned programmes, the operational-system design seems highly efficient. Educational institutes run a complex well-balanced operational system, which shows a strong vertical integration, obviously to prevent unnecessary dependencies from their environment in order to avoid disturbances of the educational process. Institutes usually have their own teaching staff, buildings, and other facilities for the full capacity needed. Therefore, in HPE, the need for resource flexibility (Starr, 1989) is obviously low, due to a large own teaching staff, full capacity accommodation, personal equipment and rather standardized teaching and learning processes. Work force is a main resource, using nearly 70% of the budget (CBS, 2000). Teachers are skilled professionals with a uniform role, generally trained for teaching activities and prepared to act autonomously in a wide range of teaching situations. At the same time, they are normally specialized in one scientific discipline or professional field, which severely restricts the flexibility of their deployment. Main facilities are buildings for face-to-face teacher-student interaction, with many standard-format classrooms, ready to receive any class group for any subject at any lesson period in the schedule, using the available accommodation as efficient as possible. To prevent resource competition, all students get their own copies of frequently needed study-books.
In education, customer involvement (Chase & Aquilano, 1989) has a unique place, compared to other service organizations. In HPE, students normally spend 30 - 40 hours weekly for a period of four study years to complete an educational programme. During this period, the common full-time educational format practically seems to dominate the life of students. An almost exclusive educational domain is created, preparing students for, but also preventing them from gradually developing their

participation in the real world of work and living. Nevertheless, education has at its best a supportive role for the learning and development of the students. The related learning processes mainly depend on the personal qualities and motivation of individual students, whose individual differences undoubtedly influence these activities, their pace and results. Therefore, customer orientation must be considered as essential for educational institutes. But in the common educational programmes, students do not seem to have much influence on the study activities in which they participate.
With respect to capital intensity (Chase & Aquilano, 1989; Krajewski & Ritzman, 1996) for teaching, education still depends primarily on the knowledge and skills of people trained for the teaching profession. For the learning of students, study books still play a dominant role. Technology-based teaching and learning (e.g., in distance education and e-learning) generally plays a modest role, when the relative small numbers of students involved are considered. Until now, technical equipment (i.e., ICT) does not yet seem to have a substantial impact on main educational processes in HPE, so the capital intensity can be considered as low.
Resuming the preceding walk through the operations-management framework for the positioning of organizations, it may be concluded from the earlier survey results that Dutch HPE institutes in the BA field can be considered as service organizations in which the operational processes are organized with a clear product focus. Process choice is a highly standardized linear programming approach combined with batch processing. Vertical integration is strong in order to keep the dependency on resource flexibility to a minimum. Customer involvement is essential, but without much influence of students. Processes mainly depend upon highly skilled, specialized labor force, and have a relative low capital intensity.

Increasing the flexibility by means of simulation

For increasing the flexibility of educational programmes, a further analysis of educational institutes is necessary. Compared to other service organizations (e.g., hospitals, banks and restaurants), educational organizations seem to have some typical, specific features in addition to the formal characteristics of the operations-management positioning framework. In line with the survey results (Schellekens et al., 2003), it may be noticed that students in HPE normally have a stable, long-lasting and exclusive service relationship with one specific educational institute. Full-time involvement is a normal pattern for students and for many teachers, making education a self-sufficient process, which is relatively isolated from its environment. Distinguishing educating and learning as different processes may reveal, that input and output have a complex, indirect and long-term relationship. In the usual format, the operational system is highly elaborated, well-balanced and severely standardized, while the processes are normally very labor intensive and time consuming for the students as well as for the teachers. For a first analysis, increasing the flexibility of educational programmes is considered therefore within the context of one specific educational institute.
HPE institutes are service organizations with a product-focused strategy, which requires restricted numbers of standardized professional profiles (e.g., fitting to a format of four years of study and standard exit qualifications) for restricted categories of

students (e.g., with respect to preliminary training and study conditions), requiring larger numbers of students, in order to keep the costs low. Customizing educational services to meet the specific demands of individual students, would require a more flexible process-focused strategy, which matches with many varied profiles, each of them with relative small numbers of students. When a product-focused strategy is maintained, the customizing of educational programmes would lead to higher costs for vertical integration, teacher specialization, facilities and equipment. Increasing the numbers of students as such, does not solve this problem. In The Netherlands, HPE institutes were involved in a merging process in order to improve their service level and to reach a better cost-benefit balance (Kouwenaar & Stannard, 1988). But maintaining the original structure of departments, programmes and variants, does not seem an obvious way to realize the intended improvements. For taking advantage of economies of scope[1] (Krajewski & Ritzman, 1996; Starr, 1989), it is necessary to redesign the organization and to re-engineer the operational processes, in order to keep the two apparently conflicting priorities of customizing and cost control in balance.

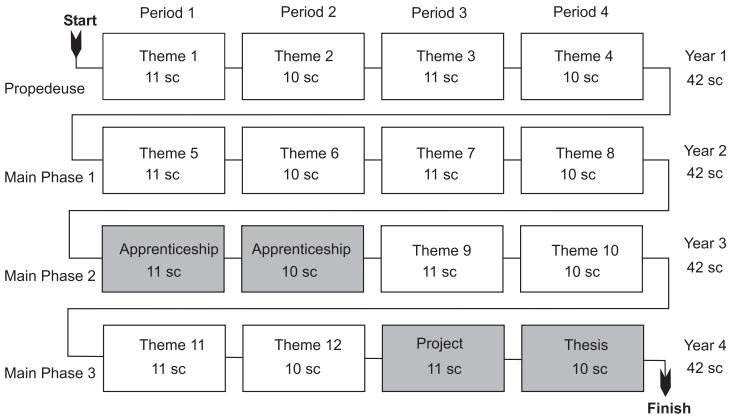

Figure 1. Programme diagram. Diagram of a 4-year study programme of 168 study credits (equals 240 ECTS), organized in 16 study periods. Gray boxes contain individual units.

Schellekens et al. (2003) found that educational programmes consist of study units, which are normally planned in one of 16 study periods, according to the programme diagram in Figure 1. From an analysis of curricula and programmes, two kinds of study units could be determined with respect to the educational approach: units studied in classes ('class units'), and units studied individually ('individual units'). The class units are preprogrammed in one of the twelve thematic study periods of a programme. Class units, typically, are offered each year in just one of the four yearly study periods. Students who miss a class unit, normally have to wait one year for the next

[1] Economies of scope is the ability of an organization to produce multiple products or services more cheaply in combination, than separately.

occasion. The individual units include an apprenticeship[1] period and a final study period for an individual project and thesis, - covering together about four study periods -, and a restricted number of other small individual-study units. Basically, individual units are not restricted to one single study period. For these units, students are less dependent on the educational planning of the institute and relatively free to plan their own programme participation and activities. With respect to these differences, failing to pass class units can easily cause study delay and non-active study periods for a student, which is not the case for individual units.
A possible way to improve the flexibility of an educational programme for the students is to transform class units into individual units, replacing for these units the linear programme planning by an individually sequenced planning, thus preventing delay and waiting periods. Usually, such a transformation would require a change from working in classes into an individualized approach. From an operational point of view it can be argued that increasing the relative proportion of individually sequenced study units, according to a process-focused operational strategy, will improve the flexibility of educational programmes. It is possible to make use of economies of scope by selecting those class units which are common to all the specific programmes: normally study units regarding instrumental or supporting skills, like generic computer- and software-application skills, language, presentation and communication skills, and use of statistical methods. Transforming these class units into individual units creates a curriculum for an individually sequenced parallel programme, which can be customized more easily to the needs of individual students (see Figure 2). A curriculum which allows for an increased individually planned programme part will enable more flexible programmes, compared to programmes based on the linear planning in classes of the original curriculum.

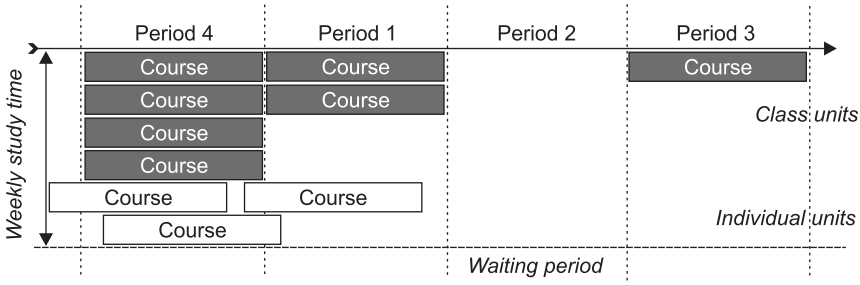

Figure 2. Partial Flexible Model. Individualized programme procedure. Shows a part of the programme of an individual student, according to the partial flexible model of the first case study.

[1] In Dutch HPE programmes, an apprenticeship is a period (normally a semester) in which students autonomously perform a task or a project in a professional organization or situation outside the school for gaining experience and competence development.

This line of reasoning leads to the research question of this study: Are educational programmes with an increased proportion of individually planned study units more flexible than programmes with a class-group based planning? For this study, the curriculum is considered as a complex experimental variable underlying two programme variants: a 'class programme' and an 'individual programme', the latter with an extended proportion of individually sequenced study units. Increased flexibility is expected to lead to reduced study duration and waiting time for students who participate in the individual programme variant.
Ideally, this research question could be answered by a case study, in which the available curriculum and the corresponding programmes, as proposed, are changed according to an 'individual programme' approach. However, this would be difficult because of the drastic changes and the large scale which is required for a realistic experiment in an existing educational institute. Operations management has several approaches available for studying operational systems in order to support design decisions. Simulation is an approach in which the operation of a real world process or system over time is imitated and experimented with, usually with specific simulation software on a computer (Banks, 1998). This approach is especially useful for analyzing the behavior of complex systems, for which often no other suitable methods are available. Simulation can also be applied when it is too costly, time-consuming or too difficult to try out alternative designs for solving problems in the real world. Furthermore, a simulation model can provide insight which can not be reached by experiments in the real world or by plain calculations.

Case study
Next, the approach is described in which a case study is used to answer the research question and to find out concurrently whether simulation is useful to study effects of changes in educational programmes on flexibility. In this case study, real data of a specific educational institute are used to develop a simulation model of the educational system, which is applied in a simulation experiment. In the experiment, the existing 'class programme' of the educational institute is compared with a new design for an 'individual programme', in order to consider the effect of this change on flexibility. Finally, the approach is validated by representatives of the case institute in order to answer the research question.

Case institute. In line with the preceding survey study (Schellekens et al., 2003), a HPE institute in The Netherlands with programmes in BA was selected for the case study. These programmes, which included business economics, commercial economics and logistics, fitted the operational format in Figure 1. Each programme of nominally four years of study consisted of a one-year introductory phase ('propedeuse'), followed by a three-year main-programme phase ('main phase'). A study year of 42 study weeks was organized in four study periods of 10 or 11 study weeks. One study week (nominally 40 hours of study) equals one study credit[1] (sc). Each programme was structured according to a curriculum of 12 thematic and 4 non-thematic study periods. The thematic study periods were actually composed of 378 study units (modules), with a

[1] A study credit (sc; unit of credit, or study point) is equal to a week of study, or 40 nominal study hours.

study load of 1 sc (38% of the modules), 2 sc (59%) or more study credits (3%), which were planned for a total of 10 or 11 sc in each study period. The non-thematic study periods were used for apprenticeships, a final study project and writing a thesis. As usual, each programme counted 168 sc in total, which equals 240 ECTS. Related programmes had the first study year (propedeuse) in common.
The institute had a student population of about 1070 students for BA with a yearly intake of about 300 new students. The students were organized in 58 permanent groups, based on programme choice and cohort. The educational staff counted about 110 qualified teachers, with a teacher capacity of 68 fte (full-time equivalent), of which 37 fte was actually available for interactive activities with students (e.g., lessons, coaching). The accommodation, which included 30 standard-sized classrooms for a maximum of 30 students each, had a total capacity for more than 2000 students, and was also in use for other faculties.

Table 2. Class-programme and Individual-programme variant (Study credits)

Programme units	Period 1		Period 2		Period 3		Period 4		Total	
	cls	ind	cls	ind	cls	ind	cls	ind	cls	ind
CP variant										
Year 1	10	0	10	0	10	1	10	1	40	2
Year 2	10	0	10	0	9	2	9	2	38	4
Year 3	10	1	10	1	0	10	0	10	20	22
Year 4	11	0	9	2	0	10	0	10	20	22
Total	41	1	39	3	19	23	19	23	118	50
IP variant										
Year 1	5	5	5	5	10	1	10	1	30	12
Year 2	5	5	5	5	9	2	9	2	28	14
Year 3	5	6	5	6	0	10	0	10	10	32
Year 4	6	5	4	7	0	10	0	10	10	32
Total	21	21	19	23	19	23	19	23	78	90

Note. Units: cls = Class study units; ind = Individual study units; Period = Study period.

Problem definition. A selection of 148 study units could be determined as a common curriculum for six BA programmes. Each programme (168 sc in total) consisted of class units (118 sc) and individual units (50 sc). As argued before, transforming class units into individual units, would have a positive effect on flexibility. An analysis of the curriculum showed, that the class units for instrumental and supportive skills were mainly planned in the first two study years, and normally covered about 40 sc in each programme. Transformation of these class units into individual units, created a new curriculum with an increased proportion of individual study units compared to the original curriculum. Table 2 gives an overview of the original and the new programme variant. Class Programmes are based on the original curriculum with a normal proportion (50 sc) of individual units. Individual Programmes are based on the new curriculum with an increased proportion (90 sc) of individual units, and a more proportional distribution in a programme. Next, a conceptual model of the case institute is described, which served as a basis for the development of a simulation model.

Conceptual model. The institute offers six BA programmes, which nominally require four years of study. A study year has four successive study periods, each with class and individual study units for a total of 10 or 11 sc. Class units are coupled to one of the four yearly study periods, making it possible to go on ahead or to make up for class units of the same study period in earlier study years. Individual units are *not* coupled to specific study periods or study years.
At the beginning of a study year, there is an intake of new students with a differing capability and number of weekly study hours available. Each student has a personal dossier or file, in which personal data, study programme and results are administrated. A student participates in one of the BA programmes and can obtain study credits, depending on capability, available study time, and effectivity of educational support. In each study period, a student can acquire less (by failing tests) or more study credits (by doing study units from other years). Individual units can be studied in any study period and study year, as far as a student has study time available.
A student who obtains less study credits than nominally required within a four-years study period, needs extra study time to obtain the required study credits for the class or individual study units of the programme. When, for instance, a student has completed all the individual units in a programme, it can be necessary to wait one or more study periods, in order to complete all the class units of the four study periods in the programme. In order to prevent unnecessary loss of time, studying class units must be given priority over individual units. A programme is completed when a student has acquired all the study credits for the class units in each of the four study periods, and for the individual units. A student with a total of 168 sc leaves the institute with a certificate at the end of the ongoing year. Fast students (e.g., high-capability students with much study time) may succeed in completing their programme within three years instead of the nominal four years. Instead of completing a programme, students can also drop out, that is, prematurely leave the institute without a certificate. Normally, drop-out is high in the first months of a programme and becomes lower as students move forward in the programme. However, drop-out increases again steadily when the study results stay behind and the study duration extends.
The output of the institute can be defined in terms of the numbers of certified students and dropouts, taken as part of the input (number of incoming students) over a longer period of time. With the administrated data of the students who leave the institute, the mean study duration and waiting time of the students for a given curriculum can be determined. In an experiment, the effect of different curriculum designs on study duration and waiting time of students can be compared.

Simulation model. The preceding conceptual model was used to develop a simulation model. According to Law and Kelton (2000), discrete-event simulation is a type of simulation in which state variables of a modeled system change at specific time units, driven by events. The simulation model must enable the definition of a curriculum and a corresponding study programme, in order to determine the effect on study duration and waiting time of students. Next, the simulation model is described by means of a diagram which represents its modular structure (see Figure 3). 'Time and event

control' manages the simulated processes, taking care of timing and triggering of events, for instance, start a new study year, and stop the simulation process after several years. 'Curriculum generation' generates the study units (modules) for composing the programmes. 'Intake of students' generates the incoming students with their specific characteristics at the start of a new study year. Students get a personal dossier in which at 'Programme definition' a programme is stored, in order to begin their study at 'Programme start'. At the start of each study period, 'Programme routing' determines by means of the dossiers, which class and individual units must be studied in the 'Study process'. Completed study units are assessed in 'Programme evaluation'. The obtained study credits are administrated in 'Dossier registration'. Students who completed their programme get certified at 'Certification'. At 'Report generation', the administrated study process data are stored in a data file before a student leaves the system at 'Leaving institute'.

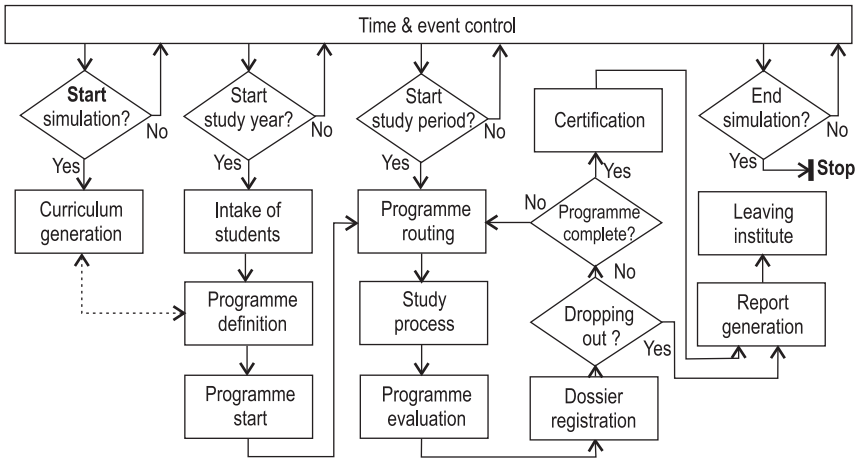

Figure 3. Simulation diagram. Main functional components of the simulation model are represented in rectangular blocks. Main decisions in the process flow are represented by diamond blocks.

The simulation model was specified by determining the parameters, variables, and entities which were needed for the implementation of the simulation model. Variables referred to input (e.g., curriculum definition, capability, study time), state (e.g., actual number of students for the institute, numbers of study credits acquired by students, student status: 'studying', 'dropped out' or 'certified'), output (e.g., certified and dropped-out students, study credits for individual and class units, study duration, waiting time), and help variables (e.g., time counters, arrays for the curriculum, programme and data in the personal dossier). Parameters were specified, for example, for the yearly intake of students, mean student population, drop-out rate, total of study credits for a programme, and effectivity of education. Entities are students and study units (modules). The simulation model and specifications were the basis for building the simulation program.

Simulation program. For the problem definition of this case study, many aspects of the real educational system were considered as less relevant for the simulation, such as the specific number and content of the programmes and study units, grouping of students, accommodation, and teacher capacity. In Dutch education, for instance, teacher capacity and classrooms are provided for the actual number of students of an educational institute.

Next, an overview is given of some important issues for implementing the simulation model in a simulation program. Detailed information of settings and values for the simulation program with respect to the curriculum, student attributes, process variables, and set up is available in Table 3. The values and distributions for determining the parameters and variables of the simulation model were calculated from, or estimated with the real data which were available from the case institute, and they were verified by its representatives.

Table 3. Simulation program details

Topics	Program details
Curriculum	
Number of study units	148
Study credits per study unit	Discrete distribution: 1 sc (40%); 2 sc (50%); 3 sc (10%)
Class programme	Class units: 118 sc; individual units: 50 sc; 168 sc in total
Individual programme	Class units: 78 sc; individual units: 90 sc; 168 sc in total
Study period	10.5 sc
Student attributes	
Student ID	Unique code for each student
Student capability (StudentCP)	Normal distribution: *M* = 1.0; *SD* = 0.2
Study time (StudentST)	Normal distribution: *M* =38.0; *SD* = 5.0
Study duration (StudentSD)	Number of study periods needed by a student
Waiting time	Number of study periods without study units to do
Study credits	Number of study credits obtained by a student
Student status	Student status: 'studying', 'drop-out' or 'certified'
Process variables	
Student intake	Normal distribution: *M* = 250; *SD* = 25
Student population	1000 - 1200 Students steadily
Student drop-out	1.2 ((1/ (StudentSC + 1)) + (StudentSD**2 / 10000))
Education effectivity (EducationEF)	Normal distribution: *M* = 1.0; *SD* = 0.1
Study success rate	EducationEF * StudentCP * (StudentTM / 40)
Maximum study duration	8 Years + 1 study period
Simulation set up	
Simulation run period	25 Study years
Warming-up period	None (empty system start)

For the implementation of the simulation model in a simulation program, several additional decisions were made. The intake of students was manipulated in order to avoid possible complications of an increasing or decreasing student population. The yearly intake of students was set to a mean of 250 students, in order to reach a stable population of about 1100 students, based on an estimated drop-out rate of 35% and a study duration of approximately 5 years, consistent with the actual data of the case institute.
For the curriculum, each study year was divided in four equal study periods, each representing 10.5 study credits. The programmes were successively generated according to the curriculum data for the Class Programme and the Individual Programme in Table 2.
At the intake, students are generated as entities with attributes, which are stored in a personal dossier. There were constant values for Student ID, Student capability and Study time, and actual values for Study duration, Waiting time, Study credits and Student status. The dossier also included two variable arrays, dimensioned 40 x 2, in which the programme of class and individual units was stored and the credits, which students acquired in each study period, were administrated. In the personal dossier all the necessary data were stored for studying a four-year study programme and determining the study results.
All students went through a study process according to a standard study programme. A student could obtain study credits for the class units available in a specific period and for the individual units which could be studied in the remaining time. Their study progress was influenced by several attributes and variables. Students acquired their study credits depending on the Study success rate, a factor related to study capability, available study time and educational effectivity of the institute, but without implementing specific test occasions. The capability of a student was perceived as a generic factor which represents, for instance, intellectual capabilities and perseverance. Each student had a personalized amount of weekly study time available. The effectivity of education was a factor which could vary the quality of educational support. The Study-success rate determined how much study credits a student acquired in each study period, with as main function to vary the study progress of the students.
For each study period the student acquired the amount of study credits for the available study units, which was determined by the Study-success factor. In order to prevent an endless study process, the individual units part and the class units part per study period were considered as completed if 1.1 times the acquired study credits equaled at least the nominally required study credits. For completed study units the nominally required number of study credits was administrated.
Students could drop out in each study period. Drop-out was generated by means of a formula using actual data for study duration and study progress (number of study credits acquired). Drop-out was considered high and rapidly decreasing at the start of a study programme. While study duration increases and a student stays behind, the chance to drop out becomes steadily higher. A study period in which a student dropped out was counted for study duration, and students got 50% of the study credits obtained in a dropout period. For technical reasons, it was decided that students must leave the institute when they exceeded a period of eight study years.

For each student leaving the institute, a record was exported to a data file. The export file contained data fields for leaving time (Year and Period), Student ID, Study duration (number of study periods), Study credits obtained (for class units, individual units and in total), Student status (studying, drop-out or certified), and Waiting time (number of non-active study periods).
The simulation program was developed in a modular structure in order to be able to demonstrate the distinct functions in the process by means of animation. For general use, several counters were available in the simulation program, such as for time (years and study periods), incoming and outgoing students, student population, dropped out and certified students. The simulation was set up for a 25-years period of education, in order to cover at least three times the maximum duration of a complete study process. At the start, there were no students in the system.

Method

Participants
For the case study, a medium-sized HPE institute with BA programmes was selected, which was representative for HPE institutes in The Netherlands (Schellekens et al., 2003). The programme coordinators of two BA faculties were directly involved in this study. They provided relevant information, discussed the problem definition and the proposed solutions, and participated in the validation of the simulation experiment. Additional procedural support for the validation was provided by an external faculty consultant.

Materials
Materials included software, hardware, documents and presentations. The software package Arena (Professional Edition, version 4.0), developed by Systems Modeling Corporation (Kelton, Sadowski, & Sadowski, 2002), was used for the development of the stochastic discrete-event simulation. This package was found suitable for the kind of problems to solve. In addition, it offered the possibility to visualize solutions, and development support was available. A personal computer was used to develop and run the simulation. The simulation program was used in the validation session to demonstrate the simulation process in an animated simulation run.
Documents were used to communicate information concerning the case institute, the problem definition, the conceptual model, the simulation model and the specifications and output of the simulation program. The document 'Information and documentation' was used to brief the participants for collecting the necessary data of the case institute. For the validation meeting, two reports were used: 1) a case description, summarizing the relevant data collected about the institute, faculties, programmes and operational processes, and 2) a simulation description, summarizing the information about the problem definition, conceptual model, simulation model, simulation programme, simulation experiment and resulting data. In the validation session, a slide presentation was used to summarize the research approach and to present a checklist of validation questions.

Procedure
For the simulation study, a step-by-step procedure was followed, according to Law and Kelton (2000). Steps in the procedure were: problem definition, data collection, conceptual model development, simulation model development, simulation model implementation, simulation experiment, and validation meeting.
At the problem definition, the transformation of class units for instrumental and supporting skills into individual study units was proposed, discussed and accepted by the participants as a viable solution for making the existing educational programmes more flexible for the students. Data collection was focused at the curricula and programmes for student cohort 1998-1999, and at operational data (e.g., numbers of students, grouping, teacher capacity, accommodation, facilities) for the study year 1999-2000. Data were used from available documents (study guides, module materials, lesson schedules), where necessary completed with information from the participants. The data were reported in a case description, which was used as a basis for the development of the conceptual model, the simulation model and the implementation in a simulation program.

Experiment
For the simulation experiment, two versions of the simulation program were created, which differed only with respect to the set of curriculum data for the programme variants: one version for the Class Programme (CP) variant, the other version for the Individual Programme (IP) variant. The simulation program and all other data (e.g., variables, parameters, entities and processes) were identical for both versions. For each of the two programme variants a separate simulation run was executed for a 25-years period of education, starting with an 'empty' educational institute and generating reports for more than 5000 students, including their data for study duration and waiting time. The simulation was technically verified during the development process. The large numbers of students in the experiment assure that the results of the experiment can be considered as statistically reliable. Replication of the simulation was used to check statistically whether the generated student numbers were within acceptable reliability margins.
The data sets of both simulation runs were used to compare the CP and the IP variant with respect to flexibility. Considering the curriculum definition as a complex experimental variable the hypothesis was tested that "... students participating in the IP variant have a shorter study duration and less waiting time than students participating in the CP variant." To test this hypothesis, the scores for study duration and waiting time of the corresponding student groups were compared by means of a chi-square test for independent groups.
The validation meeting was performed as an integrated, final step in the simulation procedure. In this meeting, which took about 2.5 hours, each step in the simulation procedure was formally evaluated for its validity with reference to the represented problem situation, following a checklist of questions and using the related materials and results from the experiment. Minutes of the validation session were taken by the researcher and drawn up in a formal validation-session report.

Results

Certification and drop-out

Each simulation run had an intake of about 6500 students, representing two independent groups of students, one for the CP variant, the other for the IP variant (see Table 4). The IP variant produced about 200 certified students more and about 100 drop-outs less than the CP variant. A remarkable difference is that in the IP variant 152 students were certified within 3 study years, compared to only 1 student in the CP variant. The numbers of certified students and drop-outs for the CP (n = 3720 and n = 1545 respectively) and IP variant groups (n = 3908 and n = 1454) were significantly different at $p < .05$, as measured with the chi-square test: χ^2 (1, n = 10627) = 6.51, p = .006 (one-tailed).

Table 4. Study duration of certified students in CP and IP variant

Number of students	CP variant				IP variant			
	abs	%	cum	% cum	abs	%	cum	% cum
Number of study years								
3	1	0.0	1	0.0	152	2.8	152	2.8
4	1747	33.2	1748	33.2	1629	30.4	1781	33.2
5	1134	21.5	2882	54.7	1115	20.8	2896	54.0
6	409	7.8	3291	62.5	637	11.9	3533	65.9
7	282	5.4	3573	67.8	224	4.2	3757	70.0
8	147	2.8	3720	70.7	151	2.8	3908	72.9
Certified	3720	70.7			3908	72.9		
Drop-out	1545	29.3			1454	27.1		
Outcoming	5265	100.0			5362	100.0		
Population	1248				1151			
Incoming	6513				6513			

Note. Data are categorized for Study years. CP = Class programme; IP = Individual programme; abs = absolute; cum = cumulative

Study duration and waiting time

Our hypothesis stated that study duration and waiting time of students in the IP variant was expected to be lower than for students in the CP variant. Certified students in the IP variant had a slightly shorter mean study duration of 4.90 compared to 4.91 study years for the CP variant (a study year = 42 study weeks). But study duration differed substantially (about half a study year) for drop-outs: 3.76 compared to 4.27 study years for class programmes (see Table 5). Measured with a chi-square test, these scores showed significant differences in favor of our hypothesis at $p < 0.5$ (one-tailed) for certified students: χ^2 (5, n = 7628) = 205.20, $p < .001$; as well as for drop-outs: χ^2 (8, n = 2999) = 37.50, $p < .001$. The mean waiting time (in study periods of 10.5 weeks) for students in the IP variant was also shorter: one week for certified

students and about two weeks for drop-outs. The hypothesis for the waiting time could also be confirmed at $p < 0.5$ (two-tailed) for certified students:
χ^2 (10, n = 7628) = 73.00, $p < .001$; as well as for drop-outs:
χ^2 (10, n = 2999) = 66.80, $p < .001$.
The results of the experiment confirmed the expectation that study duration and waiting time for students were reduced for the new, more flexible IP variant, but the differences with the original CP variant can be considered as small. However, it can be noticed that the sub category of students who really had a waiting time (waiting time > 0) in *both* programme variants (n = 2044 and n = 2082), had a substantial mean waiting time of about 3 study periods, that is 3/4 of a year.

Table 5. Study duration and waiting time of certified students and drop-outs

Student categories	CP variant			IP variant		
	M	*SD*	*n*	*M*	*SD*	*n*
Study duration						
Certified	4.91	1.11	3720	4.90	1.14	3908
Drop-out	4.27	2.83	1545	3.76	2.62	1454
Total	4.72	1.82	5265	4.59	1.75	5362
Waiting time (>= 0)						
Certified	1.34	1.85	3720	1.24	1.63	3908
Drop-out	0.98	2.24	1545	0.77	1.97	1454
Total	1.24	1.98	5265	1.12	1.74	5362
Waiting time (> 0)						
Certified	2.93	1.68	1705	2.56	1,38	1839
Drop-out	4.46	2.71	339	4.54	2,40	246
Total	3.19	1.97	2044	2.87	1.65	2082

Note. Study duration in number of study years; Waiting time in number of study periods. Waiting time (> 0) regards all students; Waiting time (> 0) excludes the students without waiting time; CP = Class programme; IP = Individual programme.

Validation
In the validation meeting the procedural steps for the simulation experiment and the resulting data were validated with reference to the research question, formulated as: "Can study duration and waiting time for the students be shortened by an individual programming of the supporting, instrumental study units?". The procedural steps were validated one by one, answering a list of related questions and using the available materials (see Table 6). All the steps were accepted as satisfactorily valid for the research question. Main remarks were made regarding the drop-out of the students (steps a, c and d) and the use of estimated variables (step d). Taking into account the remarks that were made, it can be concluded that the representatives of the problem owner approved the respective models, their implementation in the simulation programme, the simulation experiment and the results as valid for the problem setting.

Table 6. Results of the validation procedure

Procedure step (material), *validation question*, acceptation and remarks
a. Case description (case description document) *"Does the case description represent the institute correctly?"* Accepted, with the remark, that no clear data were available for the actual drop-out rate of the students.
b. Problem analysis (simulation description document) *"Does the problem analysis represent the core problem correctly?"* Accepted without remarks.
c. Conceptual model (simulation description document) *"Is the conceptual model correct as basis to solve the problem?"* The procedure for the drop-out of students was a point of dispute. Passing or failing specific study units (modules) was considered as more realistic, but acquiring a part of the study credits for a study period was accepted for this problem setting.
d. Simulation model (simulation description document) *"Is the simulation model a correct operationalization of the conceptual model?"* Accepted with the remark that variables like study capacity, study time, dropout rate, efficiency of education, were accepted as reasonable estimates, but that they would require separate validation.
e. Simulation programme (simulation description document, simulation programme diagram) *"Is the simulation programme a correct implementation to simulate the relevant processes?"* Accepted without remarks.
f. Simulation run (simulation programme demonstration run) "*Does the simulation give a correct representation of the reality that was modeled?"* Accepted without remarks.
g. Simulation experiment (simulation description document) *"Is the design of the experiment adequate to answer the questions regarding the problem setting?"* Accepted without remarks.
h. Simulation results (simulation description document, raw and elaborated output data) *"Do the results of the experiment give a realistic impression of the modeled reality?"* Accepted, with the remark that the difference in study duration for both programme variants was considered as very small. The difference in waiting time was judged as moderate.

Note. This table presents the results of the procedure steps in de validation. Each table segment contains the name of the procedure step, the materials used, the validation question, and the result.

Discussion

An operations-management approach was applied to study the flexibility of educational systems. In a case study, discrete-event simulation was used as a tool to compare an existing educational system and a modified educational-system design with a more favorable proportion of individual and group-based activities. The results were consistent with the hypothesis, indicating that the modified system with the IP variant yielded small but significant reductions in study duration and waiting time. In the available output data we found additional evidence that confirmed these results. In the individual programme variant more students were certified, less students dropped out and a substantially higher number of students was certified within three years. This last finding indicates that the flexibility indeed had increased, but mainly favored a small group of very fast students. The impact of the individualized curriculum on flexibility was probably restricted by retaining the conventional educational format of fixed study years and study periods, and the linear programming of the remaining class units, causing obviously severe thresholds for the study progress of the students. A considerable number of students in *both* programme variants had mean waiting times of several study periods, indicating that a substantial reduction of the study duration could be possible by removing these thresholds.

The use of operations-management concepts and tools in the field of education has indicated that improving the flexibility of educational systems requires a change from a product-focused to a process-focused approach. The results of the experiment show that a basic transformation to a process-focused approach may be needed to have a real impact on the flexibility of educational systems. Such a transformation urges to reconsider all the operational process design decisions which are the basis of the conventional educational systems. Doing this, the goals and the environment, which may have changed, must be taken into account, and the characteristics that appear to be essential for educational systems in the coming years must be determined.

A next step in our research is to consider the definition of a curriculum that can serve as a solid basis for a real process-focused approach. Developing new curricula and operational designs for educational programmes obviously requires the support of relevant disciplines, such as educational technology and educational psychology, in order to create a sound basis from an educational point of view. Operations management undoubtedly can provide additional support in this development, focusing on the operational aspects of educational systems, in particular on issues regarding flexibility. For future simulation experiments, the statistical foundation for the use of replication and run length of simulations may deserve closer consideration, in order to control more explicitly the reliability of the results (Law & Kelton, 2000).

Simulation, which has been already successfully applied in other areas, has also shown to be a useful tool in the field of education, where the effects of complex system changes need to be studied. In this experiment it was found especially useful to model and test new educational-system designs. Developing and demonstrating designs stimulates reflection and offers opportunities for discussion with other participants involved, enabling for instance a participatory design approach. Animated simulation revealed to be of use in bringing a new design in front of the footlights, which can help

the educational community to perceive and understand the essential structures and processes of a new conceived system design, in order to value its essential characteristics.

Chapter 4. Designing flexible programmes by simulation modeling[1]

Flexibility of educational programmes can be considered as a prerequisite for innovations in higher education. This study explored the use of concepts and tools from the field of operations management to change the format of educational programmes for increasing their flexibility. An integral flexible model was developed with operational data from a Dutch institute for HPE, using a demand-driven process-focused approach for organizing educational programmes. The curriculum was redesigned for competence-based education, according to principles of the Four-component instructional-design model (Van Merriënboer, 1997). Stochastic discrete-event simulation was used as a tool to develop the model and to test the effects of operational changes on flexibility. The simulation demonstrated that the flexibility substantially increased. Programme coordinators validated the model as a flexible solution for organizing the educational programmes of their institute, and as a contribution to innovations in higher education.

A survey study of Schellekens, Paas and Van Merriënboer (2003) indicated that the operational format of educational programmes in HPE has a negative effect on their flexibility (see Chapter 2). This format has a strong impact on teaching and learning activities, which must fit in a standard pattern of study years, study periods and weekly schedules, leaving little room to adapt programmes to the needs of individual students. Many decisions on content, activities, order, planning and educational approach are taken in advance on behalf of the students, neglecting, for instance, their prior knowledge and other important individual differences. Many institutes have modularized their programmes in order to increase the flexibility (Van Meel, 1997). But maintaining the existing format of a year-group approach and restricting time structures has, instead, caused a rigid standardization and isolation of study units (Van den Berg, 1996). To restore the coherence in the programmes, a thematic approach was introduced, in which related study modules were integrated in specific study periods. This, however, further reduced the flexibility of the programmes by making subjects and modules interdependent.

In another study, using concepts and tools from the field of operations management, Schellekens, Paas, Verbraeck and Van Merriënboer (Chapter 3) argued that educational institutes could be considered as service organizations, which support students in developing their professional competences. They proposed a process-focused approach for customizing educational programmes to the needs of individual students and to respond more flexibly to the changing needs of labor market and society. The results of a case study, in which the effects of a partial process-focused approach on flexibility were studied by means of a simulation experiment, showed that the flexibility

[1] Based on: Schellekens, A., Paas, F., Verbraeck, A., & Van Merriënboer, J. J. G. (2004). *Designing flexible programmes in higher professional education by means of simulation modeling.* Manuscript submitted for publication.

somewhat increased. However, they argued that a structural change of the operational format of educational programmes is needed to reach a more substantial increase of its flexibility.
This study aims at developing an integral model for flexible educational programmes. In a case study, information and data of an existing educational institute were used to develop a conceptual model of a department with a new flexible approach to their programmes. This model was developed and tested by means of a discrete-event computer simulation, which was validated by representatives of the institute.
To prepare this study, innovative developments in contemporary HPE are considered with respect to flexibility. Then, characteristics of flexible educational programmes are determined and design principles for flexible educational programmes from operations management and instructional design are formulated. Next, the method and the results of the validation of the flexible educational model for the case institute are presented. Finally, the research approach and results of the case study are discussed.

Flexibility in contemporary HPE

Flexibility in education is a complex issue which concerns many different aspects (e.g., Van den Berg, 1996; Van Meel, 1997; Nijhof & Streumer, 1994). According to Krajewski and Ritzman (1996), organizations can be positioned at the levels of strategic management, operational design and process management (see Chapter 3). Quality, time, place, capacity, effectivity and efficiency can be considered as strategic important aspects for educational institutes, which can be recognized in contemporary developments and responses evoked in the field of HPE. Quality concerns the aims, contents and approaches of educational programmes, which must be kept up-to-date and adequate to support the competence development of the students in the rapidly changing environment of society, its economy and labor market. Time is an important factor where the need for education steadily increases and changes. This development urges to reconsider the concept of initial education in favor of a concept of lifelong learning, in which study and work can be combined in a new and more flexible system of dual education. The place of education in a rapidly expanding world is influenced by an increasing mobility of students and teachers. This urges to reconsider the educational systems in different countries, for students to level out planning and certification barriers, and for institutes to compete in a growing international market of higher education. The capacity of educational institutes must increase to serve larger numbers of students for higher levels of education, which urges to improve the access to education for new and more diverging categories of students, and to become prepared for rapidly changing numbers of students. The effectivity of education can be increased by customizing programmes and activities to the needs of the individual students, in order to reduce drop-out and to get the most out of students, instead of aiming at standard qualifications. The efficiency of education can be improved by taking into account already acquired competences and competence levels of individual students in programmes, for instance, by using more varied planning procedures and new communication and information technology. Many developments concerning these strategic aspects share a substantial need for more flexibility.

These developments give a strong impetus for the design of a new educational model, in which learning and education no longer are considered as taking place in an artificially created area, protected for and isolated from the real world of work and society. Breaking down the barriers between the worlds of study and work, once created to raise the capacity and quality of education, could offer an attractive perspective to answer the new demands of the students in a changing society. For such a new educational model, some main trends can be specified:

1. from operating in a closed, static enclave towards interacting in a dynamic open area;
2. from a focus on initial schooling towards a focus on lifelong education on demand;
3. from a restricted, national scope towards an internationally oriented educational scene;
4. from education restricted to one institute towards education provided by multiple institutes;
5. from standard programmes for standard qualifications towards a range of unique programmes aiming at excellence;
6. from a restricted number of predefined professional and programme profiles towards customized and just-in-time educational services for clients developing themselves in work and society.

HPE institutes must respond to these trends in order to adapt their programmes to the needs of individual students and to anticipate important developments in work and society. It can be concluded that increasing the flexibility of educational programmes may have a crucial impact on the innovation and possibly transformation of education.

Characteristics of flexible educational programmes

According to Krajewski and Ritzman (1996), a new definition and design of educational services must start at the strategic level, as indicated by the strategic trends mentioned earlier, aiming at institutes which offer unique, lifelong educational services at a non-exclusive basis, cooperating and competing nationally and internationally with other educational institutes. In this wider context, the definition of flexibility needs to be reconsidered. Initially, Schellekens et al. (2003) defined flexibility as "... the extent to which students can get an educational programme that fits their educational needs, within the normal conditions of an educational institute". Flexibility was defined as 'operational flexibility', which mainly referred to the operational aspects of educational programmes, for instance, concerning learning content, grouping, selecting and sequencing of study units, available study time, pacing, and study duration. The "... normal conditions of an educational institute ..." referred to the 'means' which are usually available in educational institutes, such as teacher capacity, study facilities and accommodation. On the basis of an orientation in the field of operations management (Chapter 3), 'customizing' was identified as an important aspect of flexibility.

For developing a new more flexible model for educational programmes, a further analysis and specification of the concept of flexibility is necessary. Essentially, flexibility is the quality of adaptation. Therefore, flexibility as a strategic competitive advantage of educational institutes can be considered as the quality to adapt educational services to the needs of their clients. The initial definition and operationalization of flexibility referred to educational programmes as a given, obvious way to organize educational services for students. In HPE, conventionally formatted educational programmes can be considered as elaborated, standardized treatments of students, aiming at their qualification for specific professional profiles. Increasing the flexibility of these programmes can be interpreted as the possibility to adapt them to the needs of the individual students, including the liability to the demands of their environment. The usual format of educational programmes restricts these possibilities and is not adequate to meet the need for flexibility. For a new, more flexible educational model it seems necessary to revise the definition and the design of educational services. A new definition and design of educational services must start at the strategic level, as indicated by the strategic trends mentioned earlier, institutes aiming at unique lifelong educational services at a non-exclusive basis, cooperating and competing nationally and internationally with other educational institutes. For such a redesign the mission and aims of educational institutes need to be reconsidered, which at the operational level would lead to a more flexible operational strategy. Starr (1989), for instance, mentioned eight types of flexibility for flexible manufacturing systems, which could be applied to determine required operational characteristics of educational institutes (see Table 1).

Table 1. Operational characteristics of flexible educational institutes

The flexibility of educational institutes is characterized by ...	
Production flexibility	the range of available services
Product flexibility	create new programmes at need
Process flexibility	adapt courses to varying needs
Operations flexibility	interchange the order of courses at need
Volume flexibility	handle variations in student numbers efficiently
Machine flexibility	starting courses at need
Routing flexibility	handle programme and course disturbances adequately
Expansion flexibility	handle capacity variations structurally

Note. Adapted from Starr (1989).

Schellekens, Paas, Verbraeck et al. (Chapter 3) have proposed a process-focused strategy with a mass-customization approach, fitting a profile of services with a high degree of adaptation to the needs of clients, characterized by low volumes, matched with a high-performance design quality, a high degree of customizing, and volume flexibility. For the operational design of educational services, a new basis could be found in the principle that each individual student can have his or her own customized programme. With the development of a new operational design in mind, Schellekens, Paas, and Van Merriënboer (2003) defined a conceptual framework which was used to

determine the operational characteristics of flexible programmes in order to support this governing principle (see Table 2 and Table 3).
The characteristics are arranged according to four constructs: Environment, Curriculum, Activities and Facilities. The Environment construct concerns the complex relations and interactions of educational system and society, including factors such as attracting students, labor market needs and financial support. The related characteristics reflect important conditions for students to integrate work and study activities. The Curriculum construct defines the programmes of educational institutes, for instance, specifying their structure, content, activities and results. The characteristics reflect conditions for customizing programmes to diverging needs of students. The Activities construct concerns factors that determine how programmes are executed, including operational aspects like grouping of students, student and teacher roles, activities planning, time and facilities management. The characteristics reflect the new process-focused operational design, which enables students to plan educational activities according to their actual demands. Facilities concern the means available for programmes, such as teacher capacity and quality, accommodation and availability, information and communication means, and technical infrastructure. The related characteristics reflect an improved availability of resources, organizing the available expertise, capacity and technical facilities an a way to react more flexibly to the actual demands of the students.

Table 2. Concept definitions

Basic concepts
Activity: goal-directed behavior of persons
Situation: a coherent set of conditions for activities
Actor: a person executing activities (student, teacher, staff member)
Competence: ability to produce value-added output as a result of attitudes, skills and knowledge
Competence profile: (sub)set of competences needed for a person in a (work) situation
Educational concepts
Curriculum: the complete set of courses constituting all programmes of an educational institute
Programme: a coherent set of courses, offered in a structured way by an educational institute
Course: a coherent set of study tasks supporting the development of specific competencies
Study task: a coherent set of activities intended to develop specific competences
Work (Task): a coherent set of activities directed to produce value-added output
Study situation: situation created or modified for study tasks
Working situation: situation conditioned for work
Living situation: authentic situation of a person

These characteristics of flexible programmes were specified in order to get an operational specification of flexibility, which is meant to serve as a basis for the development of a new flexible educational model.

Principles for designing flexible educational programmes

To develop a new model for educational institutes which offer flexible programmes, design principles are needed from the fields of operations management and instructional design.

Table 3. Characteristics of flexible educational programmes

Construct	Actor	Characteristic
Environment		
	Institutes can	... quickly adapt the curriculum to the demand for education
		... quickly adapt educational programmes and offer new ones
		... offer predefined and customized programmes
	Students can	... combine (parts from) predefined programmes
		... quickly start and interrupt a programme
		... can adapt study settings to their personal situation
		... do their study tasks in work settings
Curriculum		
	Institutes can	... define programmes without using time constraints
		... define programmes in terms of competence
		... customize programmes to particular needs of clients
	Students can	... adapt programmes to their individual needs
		... adapt programmes to relevant work settings
		... adapt content and size of programmes
		... select parts or units of programmes
Activities		
	Institutes can	... adapt their educational planning to actual demands of the students
		... offer courses in several variants at need
	Students can	... functionally determine their participation in groups
		... vary their participation in group activities
		... adapt study tasks and activities to their individual needs
		... adapt study tasks and activities to their work situation
		... functionally determine their study activities
		... vary their study tasks and activities
		... plan and execute their own study activities
Facilities		
	Institutes can	... functionally use accommodation and other facilities
		... vary tasks and roles of teachers
	Teachers can	... combine several tasks and roles
	Institutes can	... deploy teachers in different roles
		... adapt the deployment of teachers to the educational demands
		... deploy teachers for the coaching of student groups
		... have work accommodation for student groups and teachers
		... have information functionally available
		... functionally use ICT for organization, communication and information

Operations-management principles
In the framework for the positioning of educational institutes (Schellekens, Paas, Verbraeck et al., Chapter 3) a positioning at the strategic management level is followed by decisions at the levels of operational design and process management. In accordance with the strategic trends specified earlier, five principles could be formulated for a new operational design of educational institutes in order to offer flexible programmes.

1. *Individual students are at the center.* The learning processes of the individual students can be considered as core processes in education. In HPE, students are young adults who have a growing responsibility for their own personal and professional development. Educational institutes have a main task in helping students to learn how to determine their aims, configure their programmes and plan their learning activities in order to use the educational services of the institute in an effective way.

2. *Educational institutes are service organizations.* Educational institutes can best be considered as service organizations (Chase & Aquilano, 1989). They support the diverging learning processes of their students in specific professional areas by offering adequate programmes for certification and custom-made programmes, which can easily be extended with related services for other clients, such as employers. Their service package is determined by a curriculum, which can be considered as a coherent framework of courses, resources and facilities.

3. *Educational services have a process-focused approach.* In order to offer customized services in an effective way, without loosing control of quality, effectivity and efficiency, a process-focused or job-shop approach is necessary (Starr, 1989). Educational institutes need to organize a wide scale of diverging programmes and activities, which may vary considerably with respect to size, content, sequencing, timing and use of resources and facilities. To offer customized services for larger numbers of students and other clients, flexible curriculum structures, a decentralized organization and adequate planning procedures are needed.

4. *Educational activities are planned on demand of students.* An important principle for organizing support activities is just-in-time delivery, based on demand-pull scheduling triggered by actual demands of clients (Chase & Aquilano, 1989). The planning of educational services must be determined by the actual demands of the students. Educational institutes need a continuous and systematic needs analysis of actual and prospective clients. ICT will play a crucial role for enabling such an approach.

5. *Resources for education are available in a flexible way.* In a process-focused or job-shop approach, resources must be organized in units for specific categories of operations (Starr, 1989). In educational institutes, human and other resources can be organized in dedicated units, in order to use expertise, teaching, coaching, and development in a flexible, effective and efficient way. For the students, efficiency can be improved by offering courses and other services in different operational patterns, which meet the actual needs of the students, according to their individual programmes and personal

circumstances. Institutes can dynamically cluster students for different courses and course formats, in order to use teacher capacities and facilities in the most cost-effective way. Services can further be improved by reconsidering the product definitions, in which the use of the available expertise and activities are extended to workers, businesses and other organizations in the local and wider environment. Again, ICT is a vital facility for the coordination of the activities, to have information available and for communication.

Instructional-design principles
To develop a new model for organizing flexible educational programmes, principles for the design of educational programmes need to be considered. The Four-component instructional-design model (4C/ID model) of Van Merriënboer (1997) provides guidelines for the design of training programmes which aim at developing specific complex cognitive behaviors or competences. The 4C/ID model supports the design of educational programmes by providing adequate strategies and methods for developing learning environments, in which realistic, meaningful learning tasks ('whole tasks') have a central and integrating role. Other components are supportive for performing these whole tasks. 'Supportive knowledge' is acquired to develop necessary cognitive schemata by means of theory and elaboration. 'Part-task practice' is meant for training coherent skills which require routine to be applied. 'Just-in-time information' is needed for developing these supporting routine skills. Whole-tasks and supportive knowledge concern learning activities which are directed to the development of non-recurrent constituent skills. Part-task practice and just-in-time knowledge represent learning activities directed to developing the recurrent constituent skills, which are conditional for developing complex cognitive behaviors.

Task-directed, discipline-directed and skill-directed activities
In HPE, where competence development in a professional context plays an important role, the 4C/ID model can offer an adequate framework for the design of educational programmes. Using the conceptual framework of the 4C/ID model, three main activities were determined in educational programmes: task-directed, discipline-directed and skill-directed activities. Task-directed activities refer to whole-task situations that provoke the development of non-recurrent constituent skills. In current programmes, the formats of these activities may vary: cases in study modules, learning projects, apprenticeships and relevant working activities in dual-education settings. Discipline-directed activities are based on scientific or professional disciplines, promoting knowledge acquisition and elaboration for developing non-recurrent skills. Activities include introductory and in-depth courses, practicals, coaching and other discipline-related support activities. Skill-directed activities refer to part-task skills-training activities, aiming at developing constituent recurrent skills, supported by prerequisite information and knowledge acquisition. Activities include, for instance, language learning, writing and presentation skills, computer skills, and use of statistical methods and tools.

Curriculum approach
In HPE programmes, task-directed activities can be considered as core activities, which may be compared to the successive task situations a trainee in a company goes through in developing the necessary competences. Discipline-directed activities, which are triggered by task-directed activities, are meant to anticipate, support and elaborate experiences in order to develop non-recurrent cognitive skills. Skill-directed activities are meant to be learned when and to the extent that they are needed in function of task-directed activities. Knowledge for the development of non-recurrent skills is mainly available as expertise of professionals, to be acquired in courses, and in group and personal coaching. Just-in-time information for the development of recurrent skills is available in practicals and by means of information facilities.
It is expected that applying these principles from the fields of operations management and instructional design can lead to the development of a new, more flexible operational model for HPE institutes, which aims at the competence development of students and takes into account the operational characteristics for flexible programmes.

2.	**Programme variants** All programmes are offered as full-time variant. Business economics, Commercial economics, Business informatics, and Management, economics & law, are also offered as part-time programmes.					
	Explanation: In part-time programmes, no difference was made in specific types of programmes, such as 'part-time modular', 'Compact programme', and 'Dual programme'.					
a.	To what extent is the issue of programme variants clear for this validation?					
	not clear - clear	– –	–	±	+	+ +
b.	To what extent is the issue of programme variants valid for this faculty?					
	not valid - valid	– –	–	±	+	+ +
c.	*Remarks:*					

Figure 1. Questionnaire sample: Question 2. from Part II: *Validation of the flexible educational model*. The original text was in Dutch.

To contribute to increasing the flexibility of educational programmes in contemporary HPE, a case study was carried out. The aim of this study was to develop an educational model for increasing the flexibility of educational programmes by redesigning the educational system of the case institute, using principles from the field of operations management and instructional design. Real data of the institute were collected and used to develop a conceptual model of a more flexible educational system. This model was implemented in a computer simulation which was used as a tool to develop and

test the flexible educational model. The simulation was validated by programme managers in order to answer the question whether the model was accepted as a feasible solution for increasing the flexibility of the existing programmes of this institute. The conceptual model and the simulation program, which were conceived and developed for this case study, are described in the method section.

Method

Participants
A medium-sized faculty for Business administration of a representative HPE institute in The Netherlands was selected for the case study. The faculty offered a cluster of six distinct programmes in full-time and part-time variants for a population of about 2000 students. Curriculum and programmes were typical for this HPE sector. Six programme coordinators and three facilities managers of the faculty were involved in this study. Three of the coordinators participated in the validation of the simulation.

Materials
The materials for this case study included a document, a questionnaire, a slide presentation and a simulation program. In the document, the case study institute and faculty were described, including the relevant information for the design of the flexible educational model and the data for the development of the simulation program.
A 35-page questionnaire, which was used for the validation of the new flexible educational model, included an introduction, and sections for the research approach (4 questions), the model (26 questions), flexibility (32 questions), and evaluation (2 questions). The questions were structured in sub-questions with Likert-type answers, using a 5-point scale, and an open sub question at the end for additional comments. Figure 1 illustrates the format of the questions. Each section in the questionnaire included a short introduction.
A slide presentation was used for the validation session and contained a general introduction, brief reviews of the research approach, the new model and the simulation, and an instruction how to use the questionnaire. A representative sample of input and output data of the simulation program was available in a handout for the respondents of the questionnaire. To complete the materials section, the conceptual model and the simulation are described next.

Conceptual model. The conceptual model describes a flexible alternative for the existing case institute in terms of programmes, intake of students and their characteristics, curriculum, educational activities, and study processes of the students.
Six full-time programmes are offered by the BA faculty of the HPE institute, four of them also in part-time mode. The programmes are based on a common curriculum and organized in courses, apprenticeships and projects. Full-time programmes count 168 study credits (sc), and part-time programmes (without apprenticeships) count 128 sc in total. The formal study duration for all the programmes and variants is four years of study. The intake of the students is once in a year at the start of a new study year. The institute starts with no students and has a yearly intake of students, aiming at a

stable student population after four to five years. Students who were taken in have a different preliminary training, which influences their study capacity and possible deficiencies in prior knowledge. Full-time students have a mean study time of 40 weekly study hours; part-time students of 29 study hours. Study capability and study time differ individually. Students select a predefined programme, which consists of a specific set of courses out of the common curriculum. Each student has a personal dossier or file for individual data, programme specifications and study results. Activities are task directed, discipline directed or skill directed. Projects and apprenticeships represent task-directed activities. Discipline- and skill-directed activities are organized in courses. Projects and courses are organized in parallel. A continuous sequence of projects is intended as an integrated core programme, aiming at the development of competences and supported by courses. Projects are organized in vertical groups (students with different programme levels) and are intensively coached by generalist teaching staff members, who are organized in 'coaching units'. For reasons of comparability, the apprenticeships of the original full-time programmes are maintained, and planned individually by the students on a full-time basis. Part-time students are compensated for apprenticeships by their relevant work experience. Courses are organized by specialized, discipline-based units of teachers ('discipline units'), which are responsible for the courses in the field of their discipline. Courses may vary in weekly study time and study duration. The planning of courses is based on the individual planning demands of the students. Students indicate in their personal dossiers which courses they need in the forthcoming period, according to their individual programmes. The discipline units collect these data on a weekly basis and decide which of their courses will start. Students decide in which courses they will participate, taking into account their available study time.

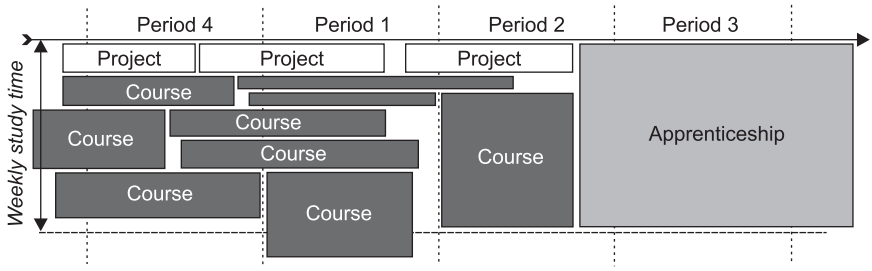

Figure 2. Integral flexible model. Part of the procedure for the study programme of an individual student, according to the integral flexible simulation model of the second case institute.

Projects are assessed by coaches in terms of competence development. Courses are assessed by tests with a success rate related to the study capability of students. Failing an exam requires extra study time and reexaminations, until a student succeeds. Students leave the institute with a certificate when they have completed their individual programmes. Students can also prematurely drop out for several reasons. For each student leaving the institute, a record of data from the personal dossier is stored for analysis, for instance, including data concerning study capability, leaving status, study

credits acquired and study duration. Figure 2 gives a graphic representation of (a part of) an individual study programme. This conceptual model was implemented in a simulation program, which is described next.

Table 4. Simulation program details

Topics	Program details
Curriculum	
Study units	16 projects, 97 courses, 5 apprenticeships
Programme variants	6 full time and 4 part time programmes
Programme size	168 sc (part time: 168 - 46 sc)
Course formats	classes, lecture, practical, individual study
Study credit	1 sc = 1 study week, or 40 hours of study
Student attributes	
Student ID	unique code for each student
Preliminary training	discrete distr. in 4 categories*: HAVO (53%), VWO (19%), MBO (19%), Rest (8%)
Programme choice	AC (13%), BE (28%), CE (22%), BI (13%), MR (19%), IL (5%) **
Study capability	normal distr.: HAVO (0.8; 0.15),VWO (1.2; 0.15), MBO (1.1; 0.15),Rest (1.0; 0.15)
Study time	triangle distr.: 36, 40, 44 hours (full-time) or 27, 29, 32 hours (part-time students)
Programme variant	part time: 60% ***
Study duration	actual number of study weeks needed by a student
Study credits	actual number of study credits obtained by a student
Student status	actual student status: 'studying', 'drop-out' or 'certified'
Process variables	
Student intake	constant: 475 students at the start of each study year
Student population	about 2000 students at the start of a study year
Student drop-out	about 27 % in total of the intake of students
Education effectivity	normal distribution: 1.0; 0.1
Project duration	triangle distribution: 6, 10, 14 weeks
Project start	90% weekly chance to start a project
Compensation period	period of 6 weeks to compensate for loss of study time
Simulation Set Up	
Study year	42 study weeks
Simulation run period	20 study years
Warming-up period	none (empty system start)

Note. *) HAVO, VWO and MBO categorize students with specific pre-training programmes; **) Accountancy (AC), Business economics (BE), Commercial economics (CE), Business informatics (BI), Management, economics & law (ME), International business & languages (IL); ***) Accountancy (AC) and International business & languages (IL) were only full time.

Simulation program. The object-oriented simulation software package D-SOL (Jacobs, Lang, & Verbraeck, 2002) was used to develop a program for a discrete-event simulation. The simulation was modeled to resemble the faculty and the BA

programmes of the case institute as closely as possible, but with a new operational approach. According to the problem setting of this case study, main aspects of the simulation were the curriculum, related study programmes, population of students, organization and planning of educational support activities, and the corresponding study processes of students. The values needed to specify and run the simulation were calculated or estimated from the data of the case institute, and verified by representatives of the institute. Table 4 gives an overview of the main simulation program details, including important variables and parameters for the curriculum, student attributes, study process and simulation set up.
The existing curriculum was first analyzed in order to redesign it according to a structure of projects, courses, and apprenticeships. Courses included discipline-directed as well as skill-directed activities. For compatibility reasons, the courses kept their original amount of study credits: in the simulation, the projects were implemented without study credits and assessments. Courses and apprenticeships (only for full-time students) covered 100% of the nominal study load (study credits). For relevant courses, extra course variants were created by varying their weekly study load and course duration, keeping the amount of study credits equal.
The original programmes were generally structured into four years of study (42 weeks), each year divided in four periods. For the students, the courses were sequenced according to these study periods, which were considered now as phases or levels in the study programme without time constraints. The study activities were planned weekly, as a result of negotiation between the discipline-based teaching units and individual students. Teacher capacity, which restricted the number of courses that could be offered by a discipline unit, was determined by the numbers of their students and the study load of the courses. Accommodation was not yet taken into account.
In order to avoid extra complications for an increasing or decreasing student population, the number of yearly incoming students was adapted to get a stable student population. The simulation run was set for a period of 20 years, in order to get acceptable confidence intervals for the means of the output data in the steady state (Law & Kelton, 2000). For demonstration and analysis purposes, files were generated with data concerning the planning of discipline units and individual students, and a file with a record for each outgoing student. This output file contained data fields for entry and leaving time (in week numbers), student attributes, programme and variant, study credits acquired, study time (in mean hours weekly), study duration (number of study weeks), and student status (drop-out factor or certified).

Simulation output data. A simulation run of twenty years, with a yearly intake of 475 students, delivered a large amount of data that could be used to analyze the main operational processes in the educational system in detail. For 10% of the students, for instance, a complete overview of their week planning was available. For the discipline units, detailed weekly overviews of demands and courses planning were available for 20 years of operation. For this case study, the data of the faculty were followed as closely as possible and compared to the existing system design, in order to be able to illustrate the effects of a new design for a flexible, process-focused and demand-oriented approach.

Table 5. Study duration and study time of certified students and drop-outs

Students	Certified				Drop-out				Total
Study duration	*M*		*SD*	*n*	*M*		*SD*	*n*	*N*
Variant	Year	Week			Year	Week			
Full time	4.5	189.43	36.38	3637	1.4	57.46	51.58	1647	5284
Part time	4.6	193.12	40.46	1902	1.3	53.55	52.82	733	2635
Pre-training									
HAVO	5.3	220.89	28.94	2240	1.5	61.83	52.29	1898	4138
VWO	3.8	158.24	22.33	1397	0.5	22.56	29.08	169	1566
MBO	4.2	174.74	27.56	1382	0.8	33.40	43.71	202	1584
Other	4.5	190.21	29.54	520	1.3	53.88	57.22	111	631
Programme									
AC	4.7	195.95	37.87	730	1.5	63.17	55.90	318	1048
BE	4.4	186.13	37.68	1631	1.2	51.68	45.86	630	2261
CE	4.6	191.22	38.14	1187	1.3	55.18	38.14	540	1727
BI	4.6	192.16	37.22	703	1.5	62.71	63.49	319	1022
MR	4.5	190.69	37.86	1028	1.3	54.24	50.48	434	1462
IL	4.7	198.21	36.24	260	1.4	56.84	55.86	139	399
All students									
	4.5	190.69	37.87	5539	1.3	56.26	51.99	2380	7919
Study Time									
Variant	Hours				Hours				
Full time	36.33		2.13	3637	38.49		1.80	1647	5284
Part time	26.98		1.30	1902	27.94		1.28	733	2635

Note. Study duration in mean (*M*) number of study years; Standard deviation (*SD*) in number of weeks. Study time in mean (*M*) number of study hours per week. 'Pre-training' mentions main entry streams of students for higher education in The Netherlands. 'Programme' mentions the degree programmes of the case institute, which are mentioned in Table 4.

By further developing the conceptual model, in which this approach and the characteristics for flexible programmes were implemented, it became obvious that a flexible model would result. However, the main program inputs and outputs, and the data demonstrating the operational processes, were of importance to illustrate the new flexible model and to validate it by comparing it to the original programmes and data of the case institute. The representatives of the institute used a sample of the available simulation data to validate the model.

For this article, we summarized some main output data, in order to illustrate the model as represented in the simulation program. In 20 years of operation, with a yearly input of 475 students, 9500 students were admitted, 6362 full-time and 3138 part-time students. Of these students 5396 (3572 full-time, 1824 part-time) students were certified, and 2570 students dropped out. After 20 years of operation, the faculty had an actual population of 1534 students, ready to take in 475 new students for the next study year. The mean study duration was 4.5 study years for the full-time students (in

weeks: *M* = 188.4, *SD* = 36.2) and 4.6 years for the part-time students (*M* = 194.5, *SD* = 40.0). The mean weekly study time was 36.33 (norm was 40) hours for full-time students and 26.98 (norm was 29) hours for part-time students. Table 5 gives a detailed overview of study duration and weekly study time of students. Figure 3 gives a frequency distribution of certified and dropped-out students according to study duration, which illustrates, for instance, that 1853 (33.5%) of the certified students succeeded in completing their programmes in a study duration shorter than the nominal four study years. Table 6 presents the detailed data.

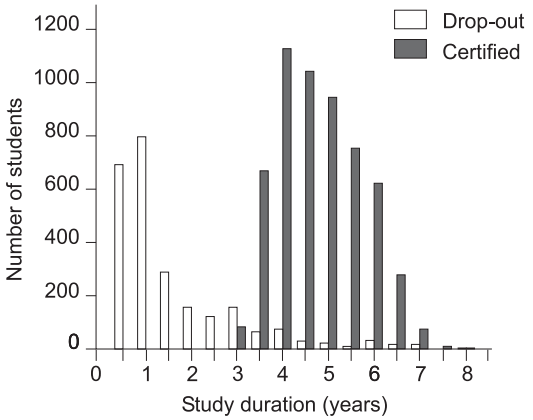

Figure 3. Study duration. Diagram of the study duration of the students in the simulation, according to the integral flexible model. Students are categorized in half-year periods.

Procedure

The research procedure consisted of five steps. First, information and data were collected for a representative description and analysis of the educational institute. Second, these data were used to develop and describe a new conceptual model of the department, meant as a redesign meeting the characteristics for flexible programmes. Third, the conceptual model was further developed and tested in a simulation model, in which the new design with flexible educational programmes was implemented as a representation of the educational institute. Fourth, the former procedure steps, the related products, and resulting output were validated by representatives of the educational institute. Fifth, the validation data were analyzed to answer the research question.

For the data collection, descriptive documents (e.g., study guides, study modules, reports), electronic sources and additional interviews with programme coordinators and facilities managers were used to produce a comprehensive document with a description of the case institute and faculty, with reference to the problem definition. The conceptual model was developed by analyzing the information and data of the case institute, with use of the operations management and instructional design principles in order to describe an educational model, which met the characteristics defined for flexible programmes (see Table 3). The development of the simulation program

was based on the conceptual model, with use of the information and data of the case institute. This model was implemented in a discrete-event simulation in cooperation with qualified simulation programmers. The simulation program was developed and tested on a personal computer. Details of the simulation program are available in Table 4. For the validation, three programme coordinators of the case institute participated in a 2.5-hours validation meeting, in which the approach, the products and results of the case study were evaluated. At the start of the meeting, the approach was briefly reviewed with a presentation. The new educational model was illustrated by means of a set of relevant print-outs from the simulation program. After an instruction, the questionnaire was used to evaluate the research approach, the flexible educational model, its flexibility, and its application. The data of the questionnaire were analyzed in order to answer the research question. To confirm the hypothesis: "The flexibility of educational programmes in contemporary higher professional education can be increased with principles from the field of operations management and instructional design", the mean scores of the respondents for all the main products on all questioned aspects were expected to be positive or at least neutral.

Table 6. Numbers of students categorized for study duration

Year	Numbers of students											
	Drop-out				Certified				All			
	Categories		Cumulative		Categories		Cumulative		Categories		Cumulative	
	abs	%	abs	%	abs	%	abs	%	abs	%	abs	%
0.0 - 0.5	689	28.9	689	28.9	0	0.0	0	0.0	689	8.7	689	8.7
0.5 - 1.0	798	33.5	1487	62.5	0	0.0	0	0.0	798	10.1	1487	18.8
1.0 - 1.5	245	10.3	1732	72.8	0	0.0	0	0.0	245	3.1	1732	21.9
1.5 - 2.0	152	6.4	1884	79.2	0	0.0	0	0.0	152	1.9	1884	23.8
2.0 - 2.5	129	5.4	2013	84.6	0	0.0	0	0.0	129	1.6	2013	25.4
2.5 - 3.0	153	6.4	2166	91.0	78	1.4	78	1.4	231	2.9	2244	28.3
3.0 - 3.5	57	2.4	2223	93.4	664	12.0	742	13.4	721	9.1	2965	37.4
3.5 - 4.0	68	2.9	2291	96.3	1111	20.1	1853	33.5	1179	14.9	4144	52.3
4.0 - 4.5	17	0.7	2308	97.0	1025	18.5	2878	52.0	1042	13.2	5186	65.5
4.5 - 5.0	13	0.5	2321	97.5	934	16.9	3812	68.8	947	12.0	6133	77.4
5.0 - 5.5	4	0.2	2325	97.7	761	13.7	4573	82.6	765	9.7	6898	87.1
5.5 - 6.0	27	1.1	2352	98.8	607	11.0	5180	93.5	634	8.0	7532	95.1
6.0 - 6.5	13	0.5	2365	99.4	293	5.3	5473	98.8	306	3.9	7838	99.0
6.5 - 7.0	14	0.6	2379	100.0	62	1.1	5535	99.9	76	1.0	7914	99.9
7.0 - 7.5	0		2379	100.0	3	0.1	5538	100.0	3	0.0	7917	100.0
7.5 - 8.0	1	0.0	2380	100.0	1	0.0	5539	100.0	2	0.0	7919	100.0
Total *(n)*	2380	100.0			5539	100.0			7919	100.0		

Note. See Figure 3 for a graphic representation of the study duration of the students.

Results

The results of the validation concern four aspects: the research approach, the validation of the flexible conceptual model as implemented in the simulation, the flexibility of the model, and the evaluation. The data were produced by means of a questionnaire, which was filled out by three programme coordinators (n = 3 for all questions).

For each aspect a number of questions and sub questions had to be answered. A detailed overview of the mean scores for the aspects and related questions of the questionnaire is available in Table 7.
In next presentation of the results, the sign '>' means 'equal to or larger than', and '<' means 'equal to or smaller than'. The research approach appeared to be clear ($M > 0.67$; $SD < 0.58$) and was accepted for all four aspects ($M > 1.00$; $SD < 1.15$). For the validation of the flexible educational model, 26 issues were questioned, which generally scored as clear ($M > 0.00$; $SD < 1.15$) and valid ($M > 0.00$; $SD < 1.73$). Relatively low, but still not negative scored Student characteristics, Accommodation, Exemptions, Programme structure, Grouping, and Educational results. Curriculum and Student outflow scored relatively high. All mean scores for the validity of the aspects or components of the model scored neutral (i.e., 0.00) or higher. The mean scores for the validity of the model in general was high ($M = 1.33$, $SD = 0.58$). The scores for the flexibility of the model were clustered according to the four flexibility constructs (see Table 3).
The scores indicate that the characteristics of flexibility generally and for all the constructs were considered as Realized ($M > 0.62$; $SD < 1.04$), that the Flexibility in the new model increased ($M > 0.95$; $SD < 1.15$), and that the conditions for Innovation were improved ($M > 0.90$; $SD < 1.15$). For the faculty of the case institute, the model was evaluated as Feasible ($M = 0.67$; $SD = 0.58$), Useful ($M = 1.33$; $SD = 0.58$), Desirable ($M = 1.00$; SD = 1.00) and Innovative ($M = 1.67$; $SD = 0.58$). For use in other institutes in The Netherlands, the model was also judged as Feasible ($M = 0.33$; $SD = 0.58$), Useful ($M = 1.00$; $SD = 0.58$), Desirable ($M = 1.67$; $SD = 0.58$) and Innovative ($M = 1.33$; $SD = 0.58$). To complete these results, it was established that there were no relevant additional remarks in the questionnaire, which could give reason to reject the results of any question.

Discussion

In this section the validation results, the research approach, and the new flexible model are considered.

Validation results
From the questionnaire scores on the four aspects of the validation, it can be concluded that the flexibility of educational programmes in contemporary HPE can be increased with principles from the field of operations management and instructional design. All mean scores except one were above zero, and a vast majority of the scores were 1.00 or higher. Nevertheless, some scores deserve extra attention. Student characteristics scored a mean of zero for Clearness and Validity, which could indicate that Study capability as a student characteristic was not well understood and appreciated. This 'clustered' factor in combination with other factors (e.g., Study time) was necessary for the simulation to cause differences in the study progress of the students in the population. But to predict study success for the learning of individual students, which for our research on operational aspects was considered as a black box, much more refined characterics and procedures would be necessary.

Table 7. Validation results (Questionnaire scores)

Q	Topics	Aspects							
Part A	Approach	Clearness		Acceptance					
		M	*SD*	*M*	*SD*				
1	Problem definition	1.33	0.58	1.33	1.15				
2	Definition of flexibility	1.67	0.58	1.67	0.58				
3	Research structure	1.00	0.00	1.33	0.58				
4	Research question	0.67	0.58	1.00	0.00				
Part B	Validation	Clearness		Validity					
		M	*SD*	*M*	*SD*				
1	Programmes	1.33	0.58	1.00	1.00				
2	Programme variants	1.67	0.58	1.33	0.58				
3	Curriculum	1.67	0.58	1.67	0.58				
4	Study duration	1.00	1.00	0.67	0.58				
5	Student population	1.33	0.58	1.33	0.58				
6	Intake of students	1.00	0.00	0.67	0.58				
7	Student characteristics	0.00	0.00	0.00	0.00				
8	Exemptions	0.33	0.58	0.33	0.58				
9	Programme structure	0.67	0.58	0.33	1.15				
10	Study units	1.33	0.58	1.33	0.58				
11	Projects	1.00	1.00	0.67	0.58				
12	Apprenticeships	1.00	1.73	1.00	1.73				
13	Courses	1.33	0.58	1.33	0.58				
14	Student dossier	1.33	1.15	1.33	1.15				
15	Discipline groups	1.00	1.00	0.67	1.15				
16	Educational demand	1.00	1.00	1.00	1.00				
17	Grouping	1.00	1.00	0.33	1.15				
18	Planning	1.33	0.58	1.00	1.00				
19	Accommodation	0.67	0.58	0.00	1.00				
20	ICT Facilities	1.00	1.00	1.00	1.00				
21	Realization	0.67	0.58	0.67	0.58				
22	Assessment	1.33	0.58	1.33	0.58				
23	Drop-out	1.67	0.58	1.33	0.58				
24	Student outflow	1.67	0.58	1.67	0.58				
25	Monitoring	1.33	0.58	1.00	0.00				
26	Study results	0.67	0.58	0.33	0.58				
27	Complete model	1.33	0.58	1.33	0.58				
Part C	Flexibility	Realization		Flexibility		Innovativity			
		M	*SD*	*M*	*SD*	*M*	*SD*		
1	Environment (7)	0.62	1.02	1.05	0.97	0.90	1.00		
2	Curriculum (7)	0.76	1.04	0.95	0.97	1.09	1.00		
3	Activities (9)	0.96	0.94	1.22	0.75	1.14	0.82		
4	Facilities (9)	1.37	0.63	1.33	0.62	1.37	0.63		
	General	0.67	0.58	1.33	1.15	1.33	1.15		
Part D	Evaluation	Feasible		Useful		Desirable		Innovative	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	Local	0.67	0.58	1.33	0.58	1.00	1.00	1.67	0.58
2	National	0.33	0.58	1.00	0.00	1.67	0.58	1.33	0.58

Note. Score range: from -2 to +2; Q = question.

Other aspects that scored low for the validity of the model were Exemptions, Programme structure, Accommodation and Study results. These aspects may require further research to find out which information was not clear and where the validity could be improved.
The relatively low scores for the realization of flexibility could express that many obvious opportunities to increase the flexibility of the programmes were not used for reasons of comparability, such as a weekly intake of students, or personal programmes.
A final comment concerns the relative low evaluation scores on the feasibility of the model, which may refer to the additional work that will be necessary to bridge the reality of an operational simulation with the lively reality of students, teachers, programmes, institutes, employers and local and national educational authorities. Therefore, this appreciation can be considered as fully justified. At the same time, the relatively high evaluation scores on Usefulness, Desirability and Innovativity may also express that it is considered worthwhile to go on with research and development activities on flexible programmes in HPE.

Research approach
The research approach for this study did clearly benefit from the use of the object-oriented simulation environment D-SOL, which provides good opportunities for the verification of the simulation model by providing detailed process and output data. The simulation program also offers excellent possibilities for experimentation with variables and parameters in order to vary the model.
This study also had some drawbacks, which deserve to be improved in further research steps. The model needs more elaboration on several aspects, such as the implementation and procedure for projects, and taking account of teacher capacity for coaching and accommodation. The input of curriculum data could be made easier by using generic parameters and variables instead of analyzing and importing a large amount of detailed data. Further, the implementation of the model in a specific case institute and the validation by representatives of the institute was a realistic and rewarding approach. But one institute and a small number of representatives requires a next step to broaden the basis for the implementation of the model in other educational institutes. It is intended to take a first step by asking educational experts to validate the flexible model in the wider perspective of innovation in HPE in The Netherlands.

Flexible model
Once the simulation is validated positively, the flexible approach in the newly designed model can be compared to the approach of the real educational institute, as said, with respect to operational issues. The output data of the simulation show that the study duration for full-time students in the simulated flexible model is 4.5 years, compared to an estimated mean of 4.3 years in the reality of the institute, which differs almost 2.5 month. However, the study duration, which usually exceeds the nominal study duration for practically all the students, now shows a large dispersion and a considerable number of students (1853 = 33.5%) with a study duration of four or less years of study. The 2.5 months extra can be understood as time lost by waiting for the start of courses or projects, which is due to the procedures for a flexible approach. This kind of

loss can eventually be reduced by using more sophisticated procedures to analyze the demands of the students and to plan the courses. In the new approach it is a task for the staff units to continuously improve their procedures and planning, including the development of the course variants that are needed.
Not visible in the output data is the gain in freedom to define new and to customize existing programmes without serious planning problems. In addition it may be noticed that study duration will become a less critical issue when a new mode of dual education will replace the isolated approach of initial full-time programmes by a more functional and realistic approach of educational services, due to strategic considerations. Another advantage is that educational institutes may loose their typical format of initial learning institutes, to adopt more and more the culture of a normal business or enterprise, still prioritizing learning, but in a more integrated, realistic, customized and just-in-time fashion of educational support. And there may still be other advantages.
Referring to flexible manufacturing systems, Starr (1989) argues that the creation of flexible systems diminishes the need for scale enlargement and centralization, increases client involvement, shortens production and delivery times, and leads to more product and price variation. But he also states that more flexible systems put higher demands to organization and coordination. Leaving the product-focused approach places the former well-balanced programmes at risk, asking extra efforts for quality control and coaching of the students.
Projects as core activities in programmes is a new educational design component which offers new opportunities for realistic team work and for intensifying the coaching of students by reallocating teaching capacities. Vertical grouping and functional student tasks can not only improve the educational effect of individual and group activities, but also offer opportunities to replace artificial educational activities by real productive work, raising additional personal and material support, and possibly extra financial means for the students, the institute or both. This component can be further developed to transform education from a dominating self-sufficient enterprise to a genuine service institute which really supports the needs and competence development of students in a flexible way.
The results of the present study suggest that changing the operational structure of educational institutes can free education from a straitjacket that has been accepted as normal for too long. Using this new freedom may enable a real transformation of education which, however, does not self-evidently lead to educational innovation. Exploring the new possibilities of a more flexible educational system is a challenge that will ask much more time, effort and investment before it can pay off. Operations management is expected to offer additional concepts and tools to support this development.

Chapter 5. Expert validation of a flexible educational model[1]

Operational flexibility is considered as an important condition for innovations in higher education. In two preceding case studies in HPE in The Netherlands, a process-focused demand-driven approach for organizing flexible educational programmes was developed. In these studies principles from operations management and instructional design were used to conceive a flexible educational model, which was developed and tested by means of discrete-event simulation. The flexible educational model is described with respect to its main development principles and operational characteristics. An initial impetus is given to examine how the flexible educational model might support actual developments and innovations in professional education. In this perspective, the flexible educational model was validated by educational experts, regarding its opportunities for practical use and impact on innovations in education. It was concluded that the flexible educational model offers a valid representation of HPE institutes in The Netherlands, and that it can increase the operational flexibility of educational programmes and improve the conditions for innovation.

Flexibility has become an important issue in HPE in The Netherlands. In a survey study, Schellekens, Paas, and Van Merriënboer (2003) argued that the flexibility of HPE programmes must be increased for several reasons. Among other reasons, the national government and the Department of Education require educational institutes to adequately handle increasing numbers of students at reasonable costs. Educational institutes want innovations for improving the quality of their educational programmes. Society and economy want educational programmes to be kept up-to-date in order to train students for new developments. Students need programmes which are customized to their educational and personal needs. In their study, operational flexibility was defined as the degree of flexibility according to a set of operational characteristics of educational programmes. It was found that programmes in HPE in The Netherlands had a typical standard operational format and a low degree of flexibility. The results indicated that for increasing the flexibility of educational programmes, the operational format of educational programmes must be changed.
In two succeeding case studies a model for organizing flexible educational programmes was developed with the use of concepts and principles from the fields of operations management and instructional design. In the first case study (Chapter 3) a partial flexible model was developed for the acquisition of instrumental skills. In the second case study (Chapter 4) an integral flexible model was developed by redesigning the curriculum and programmes for a competence-based educational approach. In each of these case studies, data from a real representative educational institute were used to develop a discrete-event simulation, in which a more flexible operational approach was applied

[1] Based on: Schellekens, A., Paas, F., Verbraeck, A., & Van Merriënboer, J. J. G. (2004). *Expert validation of a flexible educational model for higher professional education.* Manuscript submitted for publication.

and compared with the common approach. These simulations were positively validated by programme managers of both case institutes. These studies resulted in an integral model for organizing flexible programmes, in which a demand-oriented approach and a process-focused strategy were applied. In the simulation, this model was implemented using the data of the curriculum and programmes, and maintaining the educational aims and operational conditions of the case institute. This model constitutes the basis of the flexible educational model, which is the object of the present study. In the flexible educational model, the limitations of the case study were abandoned, in order to consider the model in the perspective of innovations in Dutch HPE.
In the present study, first, the common educational model is considered by resuming its development, reviewing its basic operational characteristics, and positioning it in a systems perspective. Next, the flexible educational model is described by explaining its main principles and operational characteristics, and the additional features compared to the restricted models of the preceding case studies. In addition, the flexible educational model is placed in a wider perspective by briefly reviewing a series of studies on flexibility with respect to important developments and innovations in vocational and educational training (VET) in Europe. Then, the method and results of an expert validation of the flexible educational model are described and, finally, conclusions are formulated and discussed.

The common educational model

In the past decades, the educational model in Dutch HPE has been influenced by the concentration and merging of institutes, the modularization of the curriculum and the creation of thematic programme blocks. Concentration and merging have brought organizational integration and cooperation in sharing educational resources in larger educational institutes. Modularization has standardized and systematized educational programmes, leading to common curricula, but still keeping apart the specific programmes and student groups. The thematic approach has restored the coherence in the programmes and changed the teaching and learning activities. As a result of this development, the common educational model has several important operational characteristics, which are described in some detail in order to get a concrete picture of the structures and processes of educational programmes.

Period	1	2	3	4
Year 1	Block 1,1	Block 1,2	Block 1,3	Block 1,4
2	Block 2,1	Block 2,2	Block 2,3	Block 2,4
3	Block 3,1	Block 3,2	Block 3,3	Block 3,4
4	Block 4,1	Block 4,2	Block 4,3	Block 4,4

Figure 1. Student programme structure. Diagram of the programme structure for a student. Block 3.1, 3.2, 4.3, and 4.4 concern apprenticeships.

The operational characteristics which are relevant for educational programmes can be considered from the perspectives of students and faculties. Students are focused on the study activities of their own programmes. Faculties are interested in organizing the programmes for all their students.

Student perspective. In The Netherlands, HPE students normally participate in one specific educational programme, which formally requires four years of study. A study year starts in September and lasts until the summer holiday at the end of June. Each year comprises 42 weeks of study and is usually segmented in four study periods of about 10 study weeks each. A study week nominally counts 40 hours of study, which equals 1 study credit (sc). For a student a complete four-years programme consists of 168 study credits or 6720 study hours.

Operational characteristics
Educational programmes are normally organized in classes at an educational institute. In a full-time programme, which is represented in Figure 1, students usually spend a full year in apprenticeships outside the institute. In each normal study period, students participate in a programme block with several modules (e.g., courses) for a total of 10 sc or 400 study hours. A 50-hours course, for instance, weekly requires about five study hours, of which one or two hours are normally spent in classes and the remaining three hours in small group activities at the institute and individual study at home. A week's programme requires from 5 up to 12.5 hours for each course, for a total of 40 study hours. The programmes in a block usually have a weekly repeated lessons pattern in the first eight weeks of a study period. The last two weeks are normally available for individual study in order to prepare and do tests and to present and discuss results of the students' activities. In these two weeks there are no lessons: an institute may look almost empty, except for classes doing tests or having final meetings. As far as teachers are not involved in these sessions, they can prepare their courses for the next period.

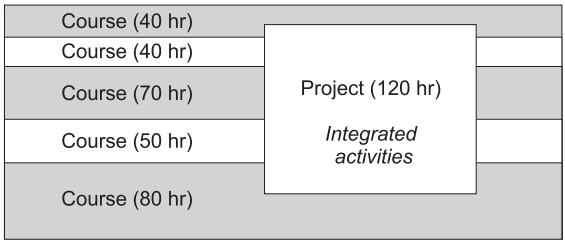

Figure 2. Thematic programme block. Diagram of the structure of a programme block, according to a thematic approach.

In a thematic approach the formerly separated courses or modules are rearranged in order to integrate subjects and disciplines, theory and practice, and to apply what was learned. For this purpose an amount of time was taken from each course in order to create, for instance, a learning project. In the example presented in Figure 2, 120

hours were taken from the original modules to spend on the integrated activities. So-called 'block books' are used for the activities planning. It can be noticed that thematic programme blocks support the idea of integrated, task-directed activities in a curriculum, but the activities are tied up in the structure of the programme block. This solution makes modules and projects interdependent, causing difficulties for doing courses without a related project or a project without the supporting courses.

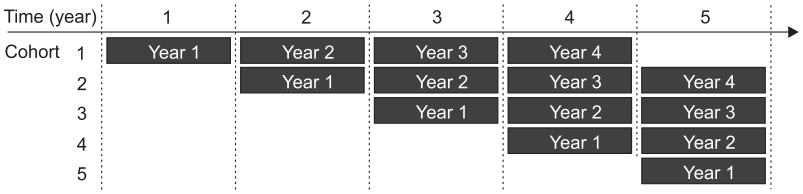

Figure 3. Institute programme structure. Diagram representing the cohorts of students in a specific educational programme.

Faculty perspective. Faculties organize programmes for year groups of students. At the beginning of each new study year, a cohort of students enters the educational institute to start one of the available programmes. Students participate in specific programme year groups, and if they manage to keep pace with their programmes, they get their certificate after four years of study. Thus, at any time normally four cohorts of students take part in the four study years of each programme, as is illustrated in Figure 3. It can be noticed that in any study year all the components of all the programmes are offered to students in one of the cohorts. Figure 4, which zooms in onto a specific programme, illustrates that apprenticeships are arranged in such a way, that at any time accommodation is required for just three instead of four cohorts of students. For the use of accommodation and related facilities it can also be noticed, that normally full-time students are at the institute during the day, and part-time students in the evening.

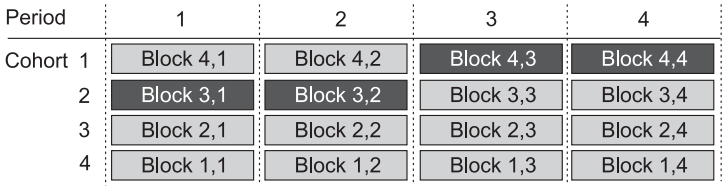

Figure 4. Institute study year. Diagram representing the participation of students in a study year from the perspective of an educational institute.

Scheduling solves the problem of organizing the study activities for cohorts and groups of students in several programmes. Each programme normally has several class groups per student cohort. A usual approach to organize programmes for these groups is to 'cross' programme blocks. Student group A, for instance, can have programme block X

in the first period and block Y in the second; while group B has block Y in the first and block X in the second period. So, the teaching teams involved in programme blocks X and Y are teaching their blocks in two successive periods. Courses for two or more student groups of a cohort can also be organized during the same study period, due to the circumstance that the teaching activities of the staff only require a small part of the study hours for the students. Periodic scheduling is a sophisticated approach to efficiently organize, for a range of programmes, the activities of several cohorts and groups of students and teaching staff, and to plan the use of accommodation and facilities.

Profile	A	B	C	D	E	F
Course 1	x	x	x	x		x
2	x	x		x	x	x
3	x	x	x	x		
4	x	x				
5	x				x	
6		x				

Figure 5. Common curriculum. Diagram representing a sample of courses in a common curriculum. For each profile a programme can be build by a selection of courses from the curriculum.

Modularization has efficiently structured the curricula in standardized modules, which can be shared by several related programmes. Figure 5 illustrates how programmes for related profiles can be build by selecting and combining modules from an available curriculum. This approach is already applied in many programmes, but a practice of cohort- and programme-based student grouping restricts the possibilities to make programmes more flexible and to facilitate the creation of new programmes.
Student and faculty perspective together create a picture of the common educational model, which illustrates its operational characteristics and its practical consequences for students and faculties in educational institutes with respect to flexibility. To complete this picture, the common educational model is considered in a systems perspective.

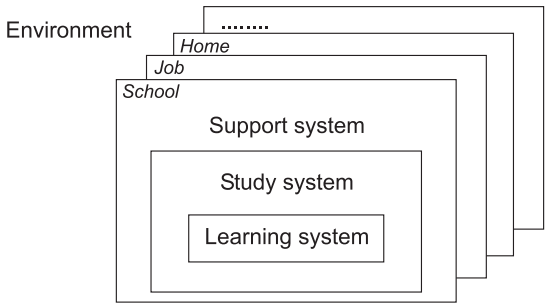

Figure 6. Educational-system structure. Structure diagram of an educational system.

Systems perspective
Schellekens et al. (2003) described a conceptual framework for educational systems, which served the analysis of educational programmes and the concept of operational flexibility. A closer look inside and outside the educational system, according to a systems approach, is needed to understand the common educational model with respect to its flexibility.
Within an educational system, as illustrated in Figure 6, three main (sub)systems can be recognized: the learning system, the study system, and the support system. A HPE institute supports the learning of individual students. Each student can be considered as a single, personal learning system, being a subsystem situated at the center of a comprehensive educational system. In this learning system the learning processes take place, which contribute directly to the development of an individual student.

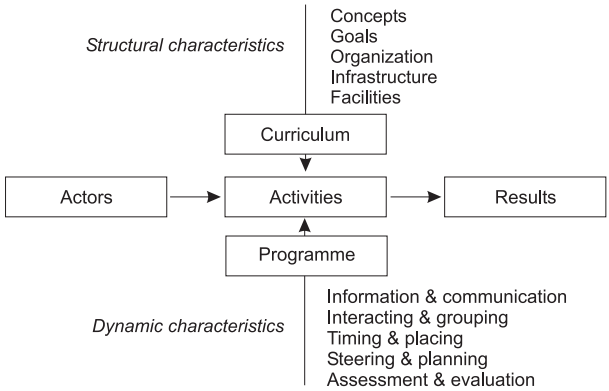

Figure 7. Educational system process. Process diagram of an educational system.

Figure 7 shows that in the study system the instructional activities of teachers, the interactions with teachers and other students, and the use of study materials and facilities can be found, which direct or influence the learning of the individual students. Teachers, consequently, can be considered as 'teaching systems' which interact with other teaching and learning systems. In this study system, teaching and learning become operational: grouping, scheduling, the use of accommodation and other facilities determine how students and teachers may act and interact. In the study system, typical arrangements can be observed, which - taken together - constitute the operational formats in which teaching and learning are implemented. In the support system the facilities, infrastructure and organization of an educational institute can be found. The personal and material resources of an institute are made available here in a certain way, in order to support the interactive processes in the study system and the learning processes in the learning systems. Teaching capacity, accommodation, and technical infrastructure, for instance, constitute important conditions to enable the operational processes in the study system. These conditions are created and maintained by the management of an educational institute.

For the operational flexibility of educational systems, the focus is primarily directed at the study system, which influences the central processes in the learning system. For increasing the operational flexibility of educational programmes, the learning system is considered as a black box, in which learning takes place.
For students, an educational institute is just one of the settings in which they live. Therefore, educational institutes need to take into account that students also live in other settings, a family and possibly a job, which serve the individual students in their own way. Students must be considered as active, goal seeking persons, who interact with others in several settings, in order to reach their own goals. Educational institutes are also positioned in an environment, where they recruit their students and educate them, for instance, to get and maintain a job. They cooperate with employers, for instance, to offer students apprenticeships. Institutes also receive financial resources of the Department of Education and must act according to its regulations. Generally, the environment determines largely the position of educational institutes, their functions and how they may operate.
From a systems perspective it can be concluded, that educational institutes are complex systems which involve thousands of students and hundreds of teachers in several faculties. Educational institutes are related in complex ways to the lives of their students and the professional world and society to which they belong. Taking into account the different perspectives of all the actors and relevant developments in the environment further increases the complexity of the educational system. This view on a complex educational reality is considerably narrowed if educational systems are modeled for the purpose of increasing their operational flexibility. In order to solve problems with respect to flexibility, it is necessary to focus on modeling the operational core structures and processes, temporarily neglecting many other aspects and their possible effects on solutions as, for instance, in simulations. This approach implies that the solutions found need to be carefully reconsidered by taking into account the complex reality of the many relevant aspects, interests and policies before they actually can be applied in education.

The flexible educational model

The flexible educational model was first developed in a case study (see Chapter 4) and then made more generic by disposing of the specific goals, programmes and operational data of the case-institute setting. In this section, main principles for the development of the flexible educational model, its operational characteristics, and additional features are described.

Main principles
In the flexible educational model the supply-oriented approach and product-focused strategy of the common educational model were replaced by a demand-oriented approach and a process-focused strategy, according to operations-management concepts. The curriculum was restructured according to the 4C/ID model (Van Merriënboer, 1997), in order to apply a competence-based educational approach.

Demand-oriented approach. In the flexible educational model, programmes are no longer considered as a standard treatment for students aiming at a particular professional profile. Students differ, for instance, in capabilities, prior knowledge, interest and study time, which influences their study programme and progress. The time students need for programmes and for specific components may vary. If their circumstances change, as for full-time and part-time students, it can be necessary to adapt the balance of time between study and work. In the flexible educational model, ideally, students have their own individual programmes stored in a personal dossier. According to these programmes, students can plan their activities to use their available study time efficiently. The planning of the educational institute is determined by the actual demands of the students.

Process-focused strategy. Programmes for related professional profiles have many components in common, which no longer justifies organizing these programmes separately for different profile- and cohort-based groups of students. To support individual students in a demand-oriented approach, the programmes are not organized any more in standardized study periods and study years. In a process-focused strategy, educational support activities (e.g., courses) can start at any moment in a year. Without fixed study periods, courses can be offered in several course variants, in which study time, course duration, and educational approach may vary. For efficiency reasons, most variants require a minimum number of students to start a course. Students can plan and use their study time in an optimal way, taking full advantage of personal capacities, prior knowledge and experience, without being obstructed or pushed by a standard programme. Institutes need to take into account the priorities of individual students in the planning of their educational support activities. As a result, the programme of each individual student has a specific operational pattern, which is illustrated in Figure 8.

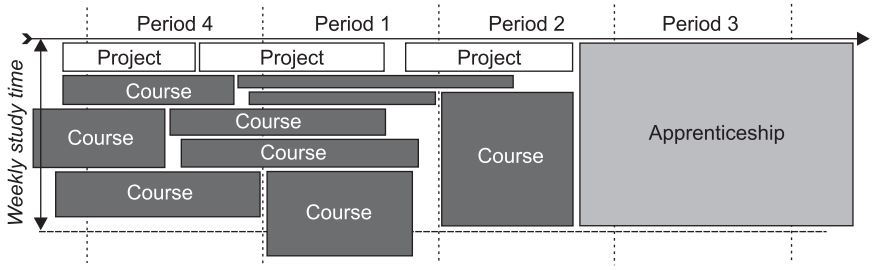

Figure 8. Integral flexible model. Diagram of a part of the programme of an individual student, according to the simulation of the integral flexible model of the second case study. This diagram illustrates the operational pattern of a programme, which is different for each student.

Competence-based education. According to principles of the 4C/ID model (Van Merriënboer, 1997), task-, knowledge-, and skill-directed activities were defined as study activities. Task-directed activities, generally, take the form of projects, which are considered as core activities constituting a programme. Preferable, projects are authentic and productive work activities in realistic settings, either in regular jobs, or in

contract work initiated by the institute or by individual students. Students participate in projects according to the competences and levels to be developed. Number and tasks of participants are functionally determined according to the nature, complexity and size of the work. Projects and tasks vary in duration and size, due to the conditions and work to be done. In the course of a programme, students participate part time in a variable number of projects, due to their needs and progress in competence development. Projects are intensively coached by generic and practice-oriented members of the teaching staff, who are dedicated to a particular project for the time it lasts, usually one to several months. Knowledge- and skill-directed activities take the form of courses in several variants. Courses can last a few weeks and require a substantial amount of time, or several months with a limited time occupation. They can take place in a large-size lecture setting, or in an individual-learning setting, for instance, as a walk-in practical or as self-study with use of a learning package. Students are expected to participate in the courses of their programme, which they need to prepare and have to fulfill their tasks in the projects. For an adequate buildup of the study programmes, these courses can be offered according to required competences and competence levels. With a curriculum that is structured for these activities, competence-based programmes can be customized to the specific needs of individual students. Programmes consist of a varying number of projects or work, in which essential professional competences are developed, supported in a flexible way by courses to acquire the actually relevant knowledge and skills.

Operational characteristics
The flexible educational model has important operational characteristics with respect to teaching staff, planning procedures, programme implementation, assessment and certification, accommodation, and facilities.

Teaching staff. Teachers can coach projects, teach courses, or do both. Staff members who coach projects are organized according to relevant professional fields and profiles. Staff that teaches courses is organized in discipline-based staff units. Staff units have capacities according to their relative contributions to the programmes for the actual student population. Staff units operate as autonomous teams, with tasks in developing and teaching courses, or to acquire, prepare and coach projects. Teaching-staff units have their own operational patterns, which are complementary to those of the students.

Planning procedures. Coaching-staff units select or recruit students for participation in available projects, which are essential components in the programmes. A coach is involved in one project or a restricted number of projects for its complete duration. Discipline-based staff units are normally involved in running a restricted number of course variants, each in a certain stage of execution. As soon as capacity becomes available, staff units can start new projects and courses, depending on the actual demands of the students. Students have personal dossiers containing their preferences, which are frequently analyzed to decide which activities can be started.

Programme implementation. Students differ, for instance, in competence, study time and preferred course variants. Project choice and tasks are determined according to the needs of the students. In the planning of courses, differences are also taken into account. Therefore, capable students can complete their programmes faster than others. The process-focused strategy may cause some loss of time in waiting for suitable courses. This loss can be minimized by a flexible attitude of the students, who temporarily may exceed their normal study time to compensate for a period with less study time. Staff members need a comparable attitude for using the capacity of their units. Students and staff can optimize their planning according to own priorities and conditions. Students, for instance, can vary within a reasonable period the proportion of time for study and work.

Accommodation and facilities. The process-focused strategy changes education into a continuous enterprise for students, teachers and institutes. With the use of modern information and communication technology (ICT), teaching and learning are no longer limited to opening hours. Accommodation and facilities in the institute can be utilized without a conventional scheduling system. Students and teachers can have their own accommodation and facilities, to be managed for their own purposes and activities. Only a restricted amount of collective provisions remains to be managed centrally. Sophisticated and reliable ICT provisions and infrastructure are essential for a flexible planning and coordination, and to support the diverging activities of students and teachers in several ways.

Assessment and certification. Projects and courses play a complementary role in programmes and in the assessment of students. In the projects, the successive coaches judge specifically the competence development and qualities of individual students. In the courses, students can be tested as before to get credited for their knowledge of particular subjects or disciplines, and their mastery of skills. Assessment primarily focuses on the results for the development of the students, and - where needed - certification for reaching the criteria to qualify a student for a particular professional profile.

Extended features

The flexible educational model was initially developed as a flexible alternative for the specific curriculum and programmes in the setting of a particular case institute (see Chapter 4). In the case setting, many of the new possibilities for students, teachers and institutes to vary the existing programmes were not used for reasons of comparability with the existing situation. By refraining from the context of the case institute, the flexible educational model can be extended beyond this setting in several ways. With respect to programmes, for instance, educational institutes normally offer a restricted number of completely predefined programmes, aiming at qualification and certification for specific professional profiles. In the flexible educational model, existing programmes can easily (1) be modified and (2) be customized to individual students. It is also easy (3) to develop new programmes. Students can eventually (4) determine a completely individual programme to serve their personal needs. In fact, each

programme which is possible with the available curriculum components can be offered to the students without severe operational and financial restrictions. To complete the description of the flexible educational model, important new operational and educational features are briefly indicated.

Operational features. The flexible educational model has important new operational features. These operational features were derived from the characteristics of flexible programmes, which were determined and used for the design of the model (Chapter 4). Programmes, projects and courses are no longer constrained by fixed study years, study periods and fixed weekly study hours. A process-focused operational strategy with a decentralized system for planning procedures and tools, replaces a product-focused strategy with a centralized system for planning and scheduling. Students can select and combine programme parts and courses according to their needs, without loosing much time due to planning problems. In the course of their study programmes, students can individually vary the proportion of time for study and work dynamically, which enables one flexible programme variant, instead of full-time, part-time and other programme variants. Students can start and interrupt their programmes at any moment in a study year without substantial loss of time. They are grouped by their needs, for projects in vertical groups, and for courses in horizontal groups, instead of in permanent cohort- and programme-based groups. Projects can vary in number of participants, tasks, capacity and duration. Courses can vary in study time, duration and course variant. Teachers are organized in discipline-based staff units for courses, and in profession-oriented staff units for the coaching of projects, instead of in operational teams for thematic programme blocks. Institutes can offer a large variety of programmes, instead of a few predefined programmes, without limiting thresholds of student numbers. Educational services can be effectively available a whole year around, exceeding the 42 weeks of a conventional study year.

Educational features. The new operational features enable a true paradigm shift in education, which is facilitated by leveling out the persistent thresholds of the traditional operational format in educational programmes. Predefined 'educational projects' and apprenticeships can be replaced by real work in projects and jobs, in which study and work can be combined in a flexible way. The flexible educational model allows prioritizing competence development in realistic task settings. Task-directed activities can be used to build a core programme for the students, which can be customized to their individual needs. The increased operational flexibility of the model creates a new mode of 'dual education'. Realistic projects or work in a job setting can be supported by knowledge- and skill-directed activities, which can be customized to the actual educational and personal needs of the students. Student and teacher roles can be varied according to these new educational settings. Educational institutes may become true service institutes with a varied package of services in an open educational structure, where competition for quality and excellence is encouraged by motivating task settings, and by intensive coaching opportunities. The flexible educational model can give an impetus to the innovation of education and, if applied properly, to bring about a true transformation of education.

Implementation
By designing the flexible educational model according to the characteristics for flexible programmes, the model leads by definition to the operational features favoring flexibility, and enables the educational features mentioned in the preceding section. However, before the flexible educational model can actually be implemented in HPE institutes, the aims for applying the model must be clarified and decided upon. Increasing the flexibility of educational programmes can be considered as an intermediate goal, which contributes to the solution of urgent actual problems of students, teachers and institutes. But the flexible educational model can also be applied to support and anticipate future developments in the professional area and in society, in order to enable and promote necessary innovations in education. To throw more light on these and other related issues, the results of a recent international study on flexibility in vocational education and training (VET) in the European Union are explored next, in order to indicate how future developments and innovations in business, society and education may match the features and possibilities of the flexible educational model.

Developments and innovations

Nijhof, Heikkinen and Nieuwenhuis (2002) describe the results of Working Group 4 of the Cost Project, in which researchers of 16 countries were involved in the study of shaping conditions for a flexible Vocational and Educational Training (VET) system. Flexibility is considered as a complex and controversial issue, which is "the core concept of economic and educational change in our time" (p. 3). It is argued that current economic demands urge important transitions in education: from initial to lifelong learning, from traditional occupations to qualifications or competences, from school learning to work experience, from social demands to market-economy demands, from employee to employer roles. Students need sustainable competences and skills to be equipped for transferability, mobility and employability in lifelong learning and working. Trainability and learning skills prepare them for a 'learning economy', which is characterized by 'hyper-innovation'. VET systems need 'systemic flexibility' to prepare students for the future, which requires "... an enormous curricular and throughput flexibility or adaptability at all levels in the different VET systems." (p. 4). In their opinion there are no easy solutions, such as ending up with one European VET system, because VET systems are deeply rooted in national cultures and traditions, with a wide variety of legal, institutional and organizational conditions.
The authors generally confirm the importance of the flexibility concept for future developments in education. Apparently in contrast with the differences in VET in several countries, Schellekens et al. (2003) found that in higher education the operational formats within Europe show remarkable similarities. The Europe-wide introduction of the bachelor-master structure seems a step in the direction of one European system for higher education. An urgent question then becomes, whether this converging development inevitably must lead to the acceptance of the existing operational format which many European countries appear to have in common. However, the authors of the national studies come up with several interesting developments, which support the need for a flexible educational model.

Knowledge base
Mayer (2002) designates the replacement of the techno-economic Fordist industrial paradigm by the learning-economy paradigm as a major shift in economy. He argues that flexibility gets a new connotation in relation to the emerging social organization of innovation, compared with the technical organization as developed around 1900 by Taylor and Ford, which was based on cost reduction, labor division and discipline. In a learning-economy framework, information and innovation have become crucial competitive advances to keep up in the economic development. 'Codified knowledge' must be accomplished by 'tacit knowledge', which is rooted in practical experience and social interaction. Knowledge building increasingly arises from the skills, shared experiences and behavior of groups and individuals. VET still reflects the Fordist mode, directed at adaptation, transfer of codified knowledge and simple skills by authoritarian, receptive and non-participative instructional techniques. Here, flexibility is a passive and reactive approach in which "unchangeable individual skills are adapted to varieties in an unchangeable demand" (p. 25), strengthened in a regime of diversified and information-technology based mass production. In a learning economy, knowledge building and competences are at the core of flexibility: a proactive approach which aims at accessing knowledge as needs arises. All employees involved in defining and solving problems, need flexibility in terms of trainability and learning skills, and must have access to codified- as well as tacit-knowledge bases. In VET this requires to replace planned and predictable learning by constructivist and experience-based learning, flexible and just in time. Important principles for new VET systems are: shaping instead of adaptation; broader educational profiles; flexible, customizable programmes; a continuum of learning; integration of educational and other policies; accreditation of informal learning. It can be concluded that flexibility in education must be implemented according to a learning economy, in order to replace "the traditional educational processes to be consumed, well-defined from start to finish, in which students until now have been put through" (Mayer, 2002, p. 19).

Networking
Nieuwenhuis (2002) states that VET colleges are still locked in the routines of the industrial training paradigm. Networking is considered a keyword in a learning economy, in which working teams and social networks play an important role in sharing knowledge as part of informal learning processes. But the internal organization of VET colleges and the external incentive structure do not support a change to the new learning economy. In his opinion, VET colleges need support from outside the system to change into learning colleges. Learning and working inside colleges must be reorganized in order to interact with the regional economy. To adapt their services to the rapidly changing external demands, colleges are forced into external orientation and the flexibility needed to get involved interactively in the outside world of learning and work. Individual learning in colleges must be combined with organizational learning in firms, supporting in turn the development of a regional learning economy. Individual learning must be embedded in organizational learning to ensure effective, efficient and innovative performances. Strategies based on creating learning networks can support both the exchange of learning and expertise necessary for regional

development as well as the development of the competences needed to participate in an innovative economy and society. For Nieuwenhuis it is an attractive perspective to organize colleges as configurations of sectoral learning and working communities with continuous contacts to the local community. However, a major problem is how the inconsistencies of the worlds of work and learning can be bridged. These worlds, with at the work side the dimensions of production chains, professional sectors and socio-economic regions, and at the college side the educational culture, professionalism and organizational structures, differ considerably from each other.

Flexible delivery

In the Spidervet project (Nieuwenhuis, 2002), VET strategies for the regional development of small and medium enterprises in six European countries were studied. The results indicate that all participating countries experience serious problems in developing new ways of VET delivery. Colleges are convinced that redefining educational goals and learning trajectories is needed to reconstruct the educational enterprise, for instance, to create lifelong learning programmes. This newly conceived enterprise is necessary in order to make learning lively again, to have an adequate supply of worker-oriented courses, and to join innovative networks of companies. Despite this awareness, all colleges expressed to have great problems in redesigning and implementing these new educational enterprises. Geerligs and Nijhof (2002) report that several experiments with dual pathways where not successful in improving the success rate of students. From a curriculum perspective, Marhuenda (2002) expresses serious doubts whether modularization and time-driven design contribute to flexibility and acquisition of the desired core skills. He also notices that most authors in the section on pathways hardly mention attempts to improve teaching practices within colleges and programmes. Several remarks indicate that in compulsory education, rigidity, autonomy loss and double control are increasing. Nieuwenhuis (2002) states that colleges, professional profiles, learning processes and incentives require a redesign of the fundamental processes and culture in education. He concludes that "... without a systemic debate and a paradigm shift at all levels in the educational system, the margins for innovative policies at college level will remain restricted" (p. 49). As additional factors he mentions: legislation, institutional setup, organizational design, the constraints for and design of the learning processes, and not to forget, the traditional roles of teachers. College teachers are considered as important actors and resources in the design of learning communities. Teaching must become teamwork with different roles and tasks. Teachers must develop specialist knowledge and constitute effective role models for their students. Hytönen, Poell and Chivers (2002) welcome human resource development (HRD) practitioners as a possible new group of VET professionals who contribute to promote lifelong learning in enterprises.

As far as the results of this international study on flexibility in VET can be taken as relevant for current innovative developments in HPE, it can be concluded that flexibility is considered as a very basic concept for a new learning approach, which extends by far the narrow focus on operational flexibility of educational programmes in our study. At the same time, flexible delivery and teaching practices emerge here as crucial issues which emphasize the importance of operational flexibility and the need to break

through the persistent format of present educational programmes. In addition, this study exposes important issues to take into account for further research and development on operational changes in educational programmes.

Expert validation

The flexible educational model was developed and validated in a case study (Chapter 4). In this case study, the model was implemented according to the aims and constraints of the case institute, and validated as a viable alternative for the existing educational approach by managers of the case institute. But the question whether and how the flexible educational model in its full extension can be applied in HPE institutes in The Netherlands was not yet answered. Therefore, many issues for development and implementation need further consideration and additional research. In the present study, as a first step, educational experts were asked to validate the flexible educational model in order to hear their opinions on the practicability of the model, its impact on expected developments in society and intended innovations in education, and possible further implications of the model. The aim is that their opinions may give direction to further research and development activities and to find out which contributions can be expected from the available flexible educational model.
The central research question in the expert validation was: "Does the flexible educational model offer a valid representation for HPE institutes in The Netherlands and can it contribute to increasing the operational flexibility of educational programmes and improving the conditions for innovation?" Specific issues were the validation of the model in the simulation, and the evaluation of the research approach, the flexibility and the usability of the model. These specific issues were determined by a quantitative approach, which was also used in a preceding case study (Chapter 4). To determine the validity of the model as it was implemented in the simulation, important operational aspects of HPE institutes in The Netherlands were judged. According to Law and Kelton (2000), a simulation model can be considered as valid if it is clearly accepted as 'credible' for its purpose by managers involved in the context of a project. The following factors were considered for the evaluation of the research approach: the problem definition, the definition of flexibility, the structure of the research, and the research question. The flexibility of the model was determined by measuring operational characteristics with respect to environment, curriculum, activities and facilities. The model was evaluated with respect to its practicability, usability, desirability and innovativity. All these aspects were scored by means of a questionnaire. In addition to this quantitative approach, a qualitative approach was followed in the form of a group discussion. The aim of this discussion was to elicit the opinions of experts on the validity of the model for HPE institutes and on its contribution for increasing the operational flexibility and improving the conditions for innovation. Practical problems and theoretical questions were explored, leading to suggestions for future developments and research.

Method

Participants
Four experts in educational technology, representing many decades of national and international work experience and thoroughly acquainted with educational policy in the field of higher education in The Netherlands, were involved in this study.

Materials
The materials for this study consisted of a detailed description of a representative HPE institute, a slide presentation of the flexible educational model, a set of specimen from the simulation of the model for the institute, a questionnaire, and a list of topics for discussion. The questionnaire consisted of four parts, which contained Likert-type questions on the evaluation of the Research approach (i.e., Part A), the Validation of the simulated model (Part B), the Flexibility of the model (Part C), and the Evaluation of the model (Part D). The description of the institute, the specimen of the simulation, and the questionnaire were the same as used in a former case study (see Chapter 4 for more details). Additional presentations were used to introduce the validation session and to give instructions for how to fill out the questionnaire.

Procedure
The experts were invited for a five-hours validation meeting. To become acquainted with the flexible educational model, they received in advance the description of the case institute and an article on operational flexibility (Schellekens et al., 2003). The validation meeting started with an introduction and presentation of the flexible educational model. Next, the questionnaire was answered individually. The mean scores on the questions in each part of the questionnaire had to be positive, or at least neutral to reach a general positive judgment regarding the research question. To complete the session, a plenary discussion was arranged in which the validity of the flexible educational model, its practical and theoretical implications, and consequences for future development and research were discussed, according to the list of topics. The discussion was chaired by an educational expert and registered on video, in order to have a verbatim account of the results.

Results

Questionnaire scores
All the answers to the questions of the questionnaire consisted of ratings on a 5-point Likert scale with the scores -2, -1, 0, 1, and 2. The results for the Validity of the flexible educational model (Part B of the questionnaire) are presented in Table 1. The scores for the Research approach (Part A), the Flexibility of the model (Part C) and the Evaluation of the model (Part D) are presented in Table 2. In next presentation of the results, the sign '>' represents 'equal to or larger than', and '<' represents 'equal to or smaller than'.
The Validity of the Flexible educational model was rated for 26 operational characteristics (Question numbers 1 - 26 of questionnaire Part B) and for the model in general

(Question number 27), with scores for Clearness and Validity (Table 1). All the mean scores of the four experts were at the positive side of the scale. Student population (M = 0.00, SD = 1.41) and Student characteristics (M = 0.00, SD = 1.83) scored relative low on validity, with high dispersion values. Programme variants (M = 1.50, SD = 0.58), Study units (M = 1.25, SD = 0.50), Courses (M = 1.25, SD = 0.50) and Assessment (M = 1.25, SD = 0.50) received relatively high scores (i.e., all means > 1.00).

Table 1. Expert ratings of the validity of the flexible educational model

Question	Topics	Expert ratings (n = 4)			
	Aspects	Clearness		Validity	
		M	*SD*	*M*	*SD*
Part B	Characteristics				
1	Programmes	0.75	1.50	0.75	1.50
2	Programme variants	1.50	0.58	1.50	0.58
3	Curriculum	0.75	1.26	1.00	0.82
4	Study duration	1.50	0.58	1.00	1.41
5	Student population	0.75	1.26	0.00	1.41
6	Intake of students	1.25	0.50	0.75	1.26
7	Student characteristics	0.50	1.00	0.00	1.83
8	Exemptions	1.25	0.50	0.25	1.50
9	Programme structure	0.75	0.50	1.00	0.82
10	Study units	1.25	0.50	1.25	0.50
11	Projects	0.75	0.50	0.25	0.96
12	Apprenticeships	0.50	1.00	0.50	0.58
13	Courses	1.25	0.50	1.25	0.50
14	Student dossier	0.75	1.26	0.75	1.26
15	Discipline groups	0.75	0.50	0.50	1.00
16	Educational demand	1.25	0.50	1.00	0.82
17	Grouping	0.75	1.26	1.00	0.82
18	Planning	0.75	1.26	0.75	0.96
19	Accommodation	0.50	1.29	0.50	1.29
20	ICT facilities	1.00	0.00	1.00	0.82
21	Realization	0.50	1.29	0.25	1.26
22	Assessment	0.50	1.29	1.25	0.50
23	Drop-out	1.00	0.82	0.75	1.26
24	Outflow	1.00	0.82	0.50	1.29
25	Monitoring	1.50	0.58	1.00	1.41
26	Study results	1.00	0.82	0.75	0.50
27	Complete model	1.25	0.50	0.75	0.96

Note. The rating scores range from -2 to +2.

In Table 2, the scores for the Research approach (Part A), the Flexibility of the model (Part C) and the Evaluation of the model (Part D) are presented. The Research approach (Questionnaire Part A) was rated on four aspects: Problem definition, Definition of flexibility, Research structure, and Research question (Table 2). The experts rated all these aspects as Clear ($M > 0.50$, $SD < 1.26$) and Accepted ($M > 0.25$, $SD < 1.41$).
The Flexibility of the model (Questionnaire Part C, Table 2) was rated on operational characteristics with respect to the categories Environment (7 questions), Curriculum (7), Activities (9), Facilities (9), as described in Chapter 4, and in-General (1). For each of these aspects it was considered to what extent they were realized in the model (i.e., Realization), the flexibility was increased (i.e., Flexibility), and to what extent they contributed to innovation (i.e., Innovativity). The mean scores of the experts for the categories of operational flexibility are all relative high ($M > 0.43$), with highest scores for flexibility in General ($M = 1.50$, $SD = 0.58$).

Table 2.
Expert ratings: research approach, flexibility and evaluation of the flexible educational model

Part	Topics	Expert scores ($n = 4$)			
A	Research approach				
	Aspects	Clearness		Acceptance	
		M	*SD*	*M*	*SD*
1	Problem definition	1.00	0.00	1.25	0.96
2	Definition of flexibility	0.50	0.58	0.75	0.50
3	Research structure	0.75	0.50	0.25	0.96
4	Research question	0.75	1.26	1.00	1.41

C	Flexibility						
	Aspects	Realization		Flexibility		Innovativity	
		M	*SD*	*M*	*SD*	*M*	*SD*
	Environment (7)	0.68	0.9	0.86	0.97	0.43	0.84
	Curriculum (7)	0.82	1.02	1.00	0.94	0.89	0.88
	Activities (9)	0.86	0.9	1.28	0.7	1.17	0.77
	Facilities (9)	0.86	1.05	1.08	0.8	0.80	1.06
	General (1)	0.75	0.5	1.50	0.58	0.50	1.29

D	Evaluation								
	Aspects	Feasible		Useful		Desirable		Innovative	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
	Local	0.00	1.63	0.50	1.00	0.50	0.58	1.00	0.82
	National	0.25	0.5	1.00	0.82	1.00	0.00	0.75	0.50

Note. The rating scores range from -2 to +2**.** For the Flexibility aspects is referred to the number of questions. Part B of the questionnaire is presented in Table 1.

The Evaluation of the model (Questionnaire Part D, Table 2) generally concerned the practicability of the model for use in the case institute for which it was developed (Local), and for use in other HPE institutes in The Netherlands (National). For both aspects, the practicability was rated according to four modalities: feasibility, usefulness, desirability and innovativity. The model is considered Feasible to the extent that it is possible to realize the model in practice. It is considered Useful, as far as (parts of) the model can be applied with a positive effect on the flexibility of educational programmes. It is Desirable if the model is recommended for application in practice. The model is Innovative to the extent that conditions for educational innovations are improved.
The experts evaluated the flexible educational model generally as positive, with relatively low scores on Feasibility for Local (M = 0.00, SD = 1.63) and for National use (M = 0.25, SD = 0.50). Their scores for innovativity were relatively high for Local (M = 1.00, SD = 0.82) as well as for National use (M = 0.75, SD = 0.50). Referring to the Research Question for this investigation it can be established that for all the aspects represented in the four questionnaire parts the mean scores of the experts were at the positive side of the scale, which indicates that the research question was positively judged by the experts. This was also the case for the case institute managers, who rated the same aspects on the same scale (Chapter 4). To determine if the ratings of the experts in the present study differed from those of the managers in the previous study, the questionnaire scores of the experts and of the managers were compared with the non-parametric Kolmogorov-Smirnov Z test for two independent samples. None of the scaled questions from the questionnaire scored significantly different (exact significance 2-tailed; n = 7; $0.11 < Z < 0.66$; $0.14 < p < 1.00$), which indicates that the experts scores did not differ from the managers scores.

Group-discussion results
Important issues in the group discussion were the validity and usability of the model, the roles of teachers, students and management concerning the implementation of the model, and recommendations for further research and development.
The validity of the model was considered in terms of 'face validity', 'construct' or 'concept' validity, and usability for practice. The validity in these terms as well as the usability of the model in terms of its relevance for practice were considered as positive by all the experts, who indicated clearly that the 26 operational characteristics covered all the necessary aspects for a valid model. In additional remarks it was noticed, that the model embodied two aspects: the curriculum proposing a competence-based approach, and the simulation program as a tool for analyzing operational changes in the organization of educational programmes. For both aspects the model was considered as useful, with special appreciation for the simulation as a tool for providing insight in the organizational processes. For the curriculum aspect special attention was given to the need for flexibility in determining the final qualifications of students. For the implementation several critical issues were mentioned. The risk for implementation failure was considered high, with an obvious need to prepare the teachers and the students for a more flexible operational approach. Coming to new routines was considered a critical issue which requires full attention. Other critical issues deserving special

attention were: the costs and financial aspects, the content of the curriculum as a necessary aspect of flexibility, the functionality of student portfolios, and the need for adequate administrative support.
Important practical issues for implementation concerned the supply of adequate projects and how to handle differences in expertise between beginning and advanced students. For the management of institutes it was expected that the approach of the model would be appreciated as a positive contribution to solve urgent problems asking for increased flexibility. For further development it was recommended to prove the existential value of the model by modest steps in implementing the approach on a small scale with realistic goals. For further research it was suggested to apply the model for creating awareness on the flexibility issue in a larger number of HPE institutes, using the simulation as a tool for analyzing the available curriculum and experimenting with possible solutions for increasing the flexibility of educational programmes.
A final recommendation was to have a critical attitude to the application of operations-management concepts and approaches in education, such as the just-in-time concept.

Discussion

From the results it has become evident that the flexible educational model offers a valid representation for HPE institutes in The Netherlands, and that it can contribute to increasing the operational flexibility of educational programmes and improving the conditions for innovation. Although the number of experts was too small to analyze the data quantitatively, the results of the qualitative analyses seem very consistent, regarding the results from the questionnaire and the discussion of the experts, and the questionnaire results of the educational experts and the managers (see Table 6 in Chapter 4).
In the results of the questionnaire, the definition of the student population and the student characteristics required specific attention. For the purpose of the operational model, for instance, the study capability of students was not meant as a precise representation of the students' mind set, but as a blended factor which was needed to cause differences in the study progress of students. It would indeed be nice to have a sophisticated representation of student characteristics for predicting their individual study results, but this was not considered really necessary for simulating the operational processes in educational institutes. The relative low scores on Feasibility seemed to indicate the fear of implementation failure, which was expressed in the group discussion. The relatively high scores for innovativity may express the appreciation for the simulation model and for attractive operational aspects of the flexible educational model.
For the research approach in general, it can be concluded that the simulation model has played an important role in developing and testing new operational structures and processes. For further studies, this simulation model needs to be refined. Time must be treated with a real calendar and clock structure, instead of in time units, in order to get a more realistic model that includes for instance weekends in which students can plan their study activities. More sophisticated procedures are needed to match demand and supply of courses in a more realistic way, instead of presuming a planning procedure

with a scope of just one week ahead. Projects, which now were implemented mainly formally, must be related to a system of competences and competence levels, in order to be matched with real projects which require more specific roles, tasks and capacities for staffing. Next versions of the simulation must not only take the capacities of the teaching staff into account, but also the operational constraints due to accommodation and facilities. Beyond the study of existing educational systems in research settings, new aims may come into picture by the use of simulation models as tools for analyzing educational systems in practical settings for decision support, in which redesign and operations support in educational systems are regarded.
Several issues require further theoretical elaboration and research. One important line of research concerns the modeling of students according to their levels of competence development. This is of crucial importance for task definition and grouping in realistic projects, in order to bring structure in competence-based educational programmes. Another interesting line of research concerns the development of assessment procedures in such a way, that they can support the flexible operational solutions of the model. A final more general idea of the experts was, to define more explicitly which operational dimensions are influenced by different educational approaches, in order to develop profiles for describing educational arrangements.
Increasing the flexibility of educational programmes by introducing and implementing a new operational model is only one of the problems to be solved for the innovation of education. To change a well-balanced and persistent educational system which has evolved in many decades as a proven way to educate students in HPE, many critical issues must be considered. The interests of several stakeholders in education, including students and teachers, the department of education, and the future employers of the students must be taken into consideration. A new educational format must be balanced again in the social en societal context of which education is a firmly-embedded part. The consequences of changing the aims and services of educational institutes must be considered anew, in order to serve students in the local, national and international perspective of the educational network. The legal and formal frameworks for educational institutes need to be adapted nationally and internationally.
To conclude, innovation in HPE requires a basic and substantial effort, of which operational change is considered a crucial aspect. Changing the operational structures and processes in educational institutes requires the development of new procedures and arrangements for programmes and planning, which must replace the well-trusted, centralized scheduled planning of the activities of students and teachers. Coordination, communication and information will put high demands on the ICT facilities in educational institutes. And finally, educational technology will play an important role in supporting the transition to a new, more flexible educational system.

Chapter 6. General discussion

The low degree of flexibility, which restricts innovative developments in HPE in The Netherlands, is considered to be a major problem (e.g., Clarke & James, 1998; Collis, Vingerhoets, & Moonen, 1997; Ministerie van Onderwijs, Cultuur en Wetenschappen, 1997; Van den Berg, 1996; Van Meel, 1997). To study this problem, concepts from educational technology were applied in combination with concepts and tools from operations management. In a step-by-step approach, flexibility in HPE was studied and solutions were developed for increasing the flexibility of educational programmes. In this last Chapter, the research approach is briefly resumed and reviewed. The contribution of this research to educational theory is discussed, and directions for future Research & Development (R&D) are recommended. Practical implications of the flexible educational model for solving the flexibility problem in HPE are considered. Finally, some general conclusions are drawn.

Research approach

In a first step, a conceptual framework for studying operational flexibility was developed, which was subsequently used for a survey in HPE in The Netherlands. The survey results indicated that educational programmes in BA had a low degree of flexibility due to their stereotyped operational format (Chapter 2). In a first case study, a simulation experiment in one of the HPE institutes was used to compare the actual educational system with an alternative, more flexible system. The alternative system used a more flexible approach to organize educational programmes, through the application of principles and tools from operations management. The effect on flexibility was found positive but modest, due to the partial solution in which the structure of the original operational format was maintained (Chapter 3). In a second case study, a more rigorous approach to increase the flexibility was followed by designing a completely demand-oriented and process-focused educational system, according to a set of operational criteria for flexibility. Educational-design principles were used to reconstruct the curriculum into a sound basis for a competence-based educational approach. This newly designed flexible educational system was positively validated by the managers of the HPE institute involved (Chapter 4). For an expert-validation study, the flexible model of the case study was extended to a general flexible educational model. This general model refrained from the specific goals, operational data and conditions of the case-institute setting. Experts on higher education validated the model with respect to its practicability and impact for innovations in HPE institutes in The Netherlands. It was concluded that the flexible educational model is a valid representation of HPE institutes in The Netherlands, and can help to increase the operational flexibility of educational programmes and to improve the conditions for innovation (Chapter 5). Next, the research approach is discussed with respect to the concept of flexibility; the contribution of operations management; the impact of educational

design; the relevance for educational innovation, and the value of the flexible educational model.

Flexibility
The concept of flexibility was primarily defined as an operational issue, which was focused on customizing educational programmes for individual students. Consequently, increasing the flexibility of educational programmes was conceived as finding a solution for an operational problem, which is admittedly a limited approach. Flexibility in education is a very complex issue and has to do with many other aspects than only operational aspects (Chapter 2). Increasing the flexibility has an impact on, for instance, educational, social and economical aspects of supporting the learning of students in educational institutes. However, the typical operational format that was found appeared to constitute a deeply rooted, stereotyped pattern in educational programmes. Replacing this format by another operational approach is important, but it is only one aspect that may help to increase the flexibility of educational programmes. To solve flexibility problems, the flexibility concept needs to be reconsidered. Important strategic decisions regarding the position and further development of education must be taken in order to increase the flexibility of HPE programmes, taking the various aspects of its multiple functions in a continuously changing society into account.

Operations management
Concepts and tools from the field of operations management were used to solve the problem of increasing the operational flexibility of educational programmes. Operations management offered a conceptual framework to position educational institutes essentially as service organizations, which support the learning of individual students. The main concepts and principles from operations management proved to be useful to redesign operational processes in education (Chapter 3). Once the gap between the world of industrial products, manufacturing and service processes on the one hand, and the reality of educational curricula and programmes on the other hand was bridged, operations management delivered several concepts and examples for modeling educational processes and institutes according to a more flexible and customized approach. But undoubtedly many other contributions from this field of science are still left to be discovered and used for modeling education. Simulation turned out to be a useful tool to analyze, design and test operational structures and processes in education, to demonstrate new operational approaches to educational managers, and to clarify the effects of those new approaches on flexibility. The simulation models became successively more refined and informative for R&D purposes, but there is still a long way to go before we fully understand the complex problems related to flexibility. A next version of the simulation model must, for instance, include capacity issues related to accommodation and facilities, and procedures for organizing competence-based projects. The object-oriented simulation software D-SOL was appreciated as a promising environment for further studies in this field (Chapter 4). It is our conviction that further R&D in education will require a true interdisciplinary approach for solving operational problems, in order to optimize the possible contributions of both involved disciplines, operations management and educational technology.

Educational design
Increasing the flexibility of education finds a basis in redesigning curricula and programmes (Chapter 2). In the usual product-focused approach, the curricula form the blueprints for the corresponding educational programmes, in which groups of students with similar entry qualities normally are exposed to a standard treatment in order to reach a specific set of qualifications (Chapter 3). The introduction of a demand-driven and process-focused approach places competence development at the center of the educational programmes. It requires educational institutes to adapt their programmes to the continuously changing needs of the individual students in order to support their lifelong learning processes (Chapter 4). New concepts and approaches are needed to structure the curricula for organizing educational programmes in this way. But in the case studies, the existing curricula were used as a basis for building the simulation models. Main principles of the 4C/ID model (Van Merriënboer, 1997) were used for restructuring these curricula and programmes. But while current developments in education stress competences and competence development, the 4C/ID model is yet focused on the training of specific complex skills or professional competences. This makes further research necessary for developing more comprehensive and diverging curricula and programmes in HPE.

Innovation
Flexibility was considered to be an important condition for educational innovation (Chapter 1). In our studies, several external and internal motives for increasing the flexibility of educational programmes in HPE were mentioned, finding their origin in explicitly stated educational and economic policies, as well as in problems experienced in current educational practices. Increasing the flexibility of educational programmes is just an intermediate goal, which may be restrictedly perceived to solve currently experienced practical problems in HPE. But current policies and analyses of current educational programmes can not be considered as a sound basis for redesigning the educational services that are needed to anticipate and to contribute to desirable future developments in education. Actual developments in economy and society put new demands on learning and education, which must influence the design of new educational programmes and systems to support the students' learning (Chapter 5). An in-depth analysis of current trends and needs regarding expected and desired future developments in education seems necessary to uncover the guidelines that are needed as a solid basis for educational innovation and, possibly, the transformation of educational provisions in society.

Flexible educational model
A main product of our research, the flexible educational model, is meant to offer a solution for increasing the operational flexibility of educational programmes (Chapter 5). This is mainly a conceptual solution, indicating important directions for the redesign of educational curricula. These redesigned curricula are operationally organized in a demand-driven and process-focused fashion, in order to offer customized educational programmes for individual students. Currently, the flexible educational model is implemented in a case-oriented simulation model that demonstrates the

assigned effects on students' study processes. The simulation model is set up according to the data of a specific educational institute. Ideally, a more generic version of the simulation model is needed for a full implementation of the flexible educational model, in order to overcome all the restrictions of the original case setting. For implementing the flexible educational model in the daily practice of HPE institutes, expertise from educational technology is needed to make design decisions more explicit and to anticipate the whole range of possible solutions. In the available simulation program, many decisions were made more or less implicitly, and - as is normal in design processes - many aspects besides the operational aspect were presupposed. For practical implementations in HPE institutes, possible solutions must be explicitly worked out in order to compare and value their advantages and disadvantages, their effects on students' learning, and their consequences for organizing the educational support system. The available simulation program can be further developed by implementing the additional aspects and refinements that are needed to use it as a generic tool for analyzing, modeling and testing possible solutions. A further step is the development of decision making and management tools to support implementations of operational changes in HPE programmes and institutes.

Theoretical implications

The results of our research have implications for educational-design theory and for the use of operations-management concepts and tools. The survey results have shown that the flexibility of educational programmes in HPE in The Netherlands is low, and that *operational* flexibility is a usable concept for determining the flexibility of these programmes (Chapter 2). Two case studies have illustrated that changing the stereotyped operational format can increase the flexibility of educational programmes with the use of operations-management concepts and educational-design principles. Simulation proved to be a useful tool to study operational changes in educational programme designs and their effects on operational flexibility (Chapters 3 and 4). The expert validation of the extended flexible educational model has indicated that the model can contribute to innovations in education (Chapter 5). But with these positive findings a large number of new questions is raised with respect to other aspects that are important for increasing the flexibility of educational programmes. In this section, two aspects will be considered specifically: the contribution of the flexible educational model to the innovation in education, and the contribution of educational design theory, in particular the 4C/ID-model (Van Merriënboer, 1997), to the design of the flexible educational model.

Innovation

In the flexible educational model, the main operational characteristics of the common educational model have been abandoned: profile-based programmes; the format of study years and study periods; periodic lessons-scheduling; year-cohort grouping; thematic programme blocks; dedicated teaching-teams, and programme variants. Instead, other operational characteristics were defined: a common curriculum enabling any possible programme; variable course formats; flexible planning of courses; flexible

grouping of students; streams of projects and courses; general coaching, and discipline-based staffing (Chapter 4). These operational changes practically removed all foundations of the common educational model. In addition to the desire to increase the flexibility of educational programmes, there must be other weighty reasons to make such drastic changes. Also, the question can be raised whether and how an extraordinary well-balanced and stable educational system can be rearranged in its context, for instance with respect to educational, social, economic and financial aspects. Changing the operational foundations is only a start and supposes a complete and careful redefinition of the educational products and services and a consequent re-engineering of the processes that need to be arranged to realize the new educational approach. The focus of this study, however, was to increase the flexibility of educational programmes by developing a new operational approach. The flexible educational model offers such an operational approach. However, the reasons why and the purposes to which such a new approach could be applied require further discussion.

Working Group 4 of the Cost Project (Nijhof, Heikkinen, & Nieuwenhuis, 2002) provided an important input to this discussion (Chapter 5). The results of this working group indicate that a need for flexibility is directly related to current developments in society and in economy, urging important transitions in education. These transitions involve changes from initial learning to lifelong learning, from traditional occupations to qualifications or competences, from school learning to work experience, from social demands to market economy demands, and from employee to employer roles. According to the authors, educational systems structurally need flexibility in order to make these changes for "... an enormous curricular and throughput flexibility or adaptability at all levels ..." (p. 4). Important outputs from their study pay attention to changes in the knowledge-base, in networking, in more flexible forms of delivery, and in professionalism. The flexible educational model, as it was validated by the experts, can directly and indirectly contribute to these changes. Flexible delivery is an obvious first aspect where the model can directly help to increase the flexibility of education. Important constraints are removed by the introduction of flexible operational patterns, enabling a much better integration of education and work than was possible before. It is obvious that local and regional networking with business and industry will help HPE institutes to find realistic tasks for their students. Integrating real work also brings opportunities for experience-based learning into education. In addition, a flexible educational approach in which work and education are integrated, creates a need for more diverging teacher roles. Other professional contributions, such as Human Resource Development, also become important to support the individual students in their development and their choices.

As far as the results of this international study on flexibility in VET are relevant for current innovative developments in HPE, it can be concluded that flexibility is considered as a very basic concept for a new learning approach, which extends by far the narrow focus on operational flexibility of educational programmes in our study. But at the same time, flexible delivery and teaching practices emerge here as crucial issues - bringing us back to the importance of operational flexibility and need to break through the persistent format of educational programmes. In addition, this study

offers many important leads for further R&D to be taken into account when considering operational changes in educational programmes.

Educational design
In the flexible educational model, principles of the 4C/ID model (Van Merriënboer, 1997) were used (Chapter 4). The 4C/ID model offers general principles or guidelines for the development of curricula and training programmes, aiming at acquiring complex skills or professional competences, in which several constituent skills are coordinated and applied in varying contexts. For the flexible educational model the four components of the 4C/ID model were translated into three kinds of activities: task-, knowledge- and skill-directed activities. Ideally, the 4C/ID model is applied for rather specific complex skills, for instance, repairing equipment, air traffic control, literature search or handling patent procedures. Here, complex skills are quite convergent activities existing of a well-defined set of constituent skills, aiming at clearly definable and measurable exit behavior. The analysis of the complex skills is normally not all too ambiguous and can result in a well-structured training programme using the components, principles and procedures of the 4C/ID model. Essentially the training programme is an optimally structured programme for the learning process of individual students, which allows customizing to their individual competences and level of competence development. This kind of training programmes can mainly be found in companies and lower and middle vocational education, and is especially applicable to specific professional profiles at intermediate levels. Less supported in the 4C/ID model are the organization of the training processes for multiple students in pre-structured training situations as found, for instance, in existing HPE institutes. Cooperation and social interaction are taken primarily into account as essential aspects of the complex skills, and may get less attention as a structural aspect of learning situations in educational institutes. As a result, training programmes designed according to the 4C/ID model, may not easily match and fit in the existing pre-structured approach and restricted operational formats of HPE institutes. The flexible educational model may resolve that problem to a large extent. But there is also a need to further develop the 4C/ID model in order to apply it to programmes that are not aimed at teaching one professional skill, but at teaching a set of competences including nonprofessional ones (e.g., social and interpersonal skills, highly generic skills such as problem solving and critical thinking, citizenship competences, etc.).
In the field of HPE, many educational programmes show this type of complexity and contain several interrelated professional and higher-level competences to be acquired and used in varying professional profiles and patterns. These professional profiles are not convergent, but rather divergent with regard to the directions in which students are developing their competences, due to varying capabilities, predispositions, interests and circumstances. Programmes to develop competences according to these professional profiles are open-ended and must allow for the customization of processes and results. Ideally, these programmes need the flexibility as desired for learning organizations (see previous Section). The development of this kind of comprehensive and complex programmes strictly goes beyond the scope and radius of the 4C/ID model. Definitely, the model is useful for the design of programme parts regarding specific

complex skills, which may constitute important core competences in the professional profile. The general principles of the model seem also useful to bring us a step further in the general design of this kind of comprehensive professional programmes. A major change of perspective seems necessary according to the proposed learning approach, in which codified and tacit knowledge must interact. A real paradigm shift is needed to make the move from a supply-driven product-focused educational approach to a demand-driven process-focused approach, which turns self-centered educational institutes into client- and community-centered service institutes. As a consequence, a setting of authentic work activities in a realistic context must take priority over the artificial pseudo-realistic settings that are normally applied in educational programmes. Instead of designing artificial educational settings, real work settings in several arrangements can be acquired or selected on the basis of their learning opportunities for the relevant professional profiles.
In the flexible educational model, authentic projects are treated as core activities in educational programmes, but essentially all kinds of dual education combining study and work are possible, including - where really necessary - artificial learning situations. In HPE, educational programmes can be modeled along the same lines as traineeships in companies, supported by adequate courses for the training of specific skills and to acquire necessary knowledge. Real-work situations, whether or not in projects organized by the educational institute, can constitute adaptable sequences of 'whole-task situations' through which customizable educational programmes can be implemented. Students can develop the competences they need for the aspired professional profiles by participating in suitable projects, set up according to well-designed development and training schemes. A 'project career', which is dynamic and develops over time, should replace the predetermined and time-driven programme structures. Programmes can be customized to the needs of individual students by adequate staffing, carefully matching up available projects and students, and assigning tasks according to the students' current competence levels and aspired professional profiles. The acquisition of specific complex skills or professional competences can be supported by 'just-in-time education', driven by the real needs evolving from the tasks in projects or work that students are involved in. This just-in-time education provides the knowledge- and skill-directed activities that are necessary to learn to perform the whole-tasks in projects or work, according to the principles of the 4C/ID model. Intensive coaching of students and advising them on necessary knowledge- and skill-directed activities is a prerequisite to facilitate such an approach.
If we can speak of a paradigm shift in the field of education, it is a shift towards a learning society and economy as indicated by Mayer (2002), and Nieuwenhuis (2002). Educational institutes and programmes must be open for the importance of tacit knowledge, experiential learning, and a vivid interaction with their environment in networks. They should bring the real work and life situations of their individual students in the center, and support them by a flexible, customer oriented system of services. To enable such a paradigm shift, a new, more flexible operational format is a *conditio sine qua non*. The introduction of such a format requires a structural redesign of educational programmes, and a total re-engineering of the way they are organized, in order to keep up with the developments in work and society. Educational techno-

logy may offer means and ways to implement this new learning approach in education. To conclude, flexibility is not a goal in itself but a prerequisite for ongoing changes that support a paradigm shift. First, a much more flexible operational approach is necessary to sustain a transition from initial to lifelong education, which allows lifelong learners to return to their educational institutes for the training they need. New training agencies that offer web-based training cannot yet be considered as a full-grown alternative because they miss the power and the impact of the conventional educational institutes. Second, a more flexible approach is necessary to take a student-centered perspective, in which education is adapted to the needs of the students and their real- life tasks. In such an approach, the effectiveness and efficiency of education may no longer be measured in terms of standard certificates and study duration, but in the quality of offered services to support the competence development of individual students. Due to the complexity of flexibility-related problems and the continuously evolving societal setting, further elaboration on these problems and possible solutions is needed. In the next section, some directions for further R&D activities are discussed.

Directions for future Research & Development

In our review of the research approach, several directions for further research were already indicated. The flexible educational model as a new operational concept for organizing educational programmes deserves further study, which may eventually contribute to a redefinition and reconstruction of educational institutes and services. An interdisciplinary approach using models and tools from operations management may play a crucial role in the further development of the study of flexibility issues. In the field of educational technology, this may lead to a better understanding of operational issues and solutions for flexibility-related problems. For operations management, education can be a new and rewarding field of study. Especially at the level of the educational management, there is a clear need for tools for analysis, decision making, and operational support; this may be an impetus for the development of more specific contributions from operations management.
A more general topic for future study is broadening the concept of flexibility, taking not only the operational aspect but also other aspects into account. The study of social-psychological aspects, for instance, can explore the impact of a flexible operational approach on the tasks and responsibilities of students and teachers, on requirements to vertical grouping, and on approaches to coaching. These and other studies may contribute to the elaboration of strategic issues in reconsidering the role and position of education in society. Research on flexibility in education must not only solve current problems, but also anticipate future demands on education, support innovation and, where at stake, transformation of educational services. In the field of educational technology, the design of educational programmes and, more in general, the approach of educational institutes deserves serious attention. Many studies in educational design focus on specific and detailed problems in learning and support processes, taking the structures and contexts offered by the providers of education as given, fixed constraints. Our study indicated that these general aspects or constraints

might constitute a 'hidden curriculum' that can have an important influence on the learning of students. Educational-design theory needs to take the consequences and effects of these general aspects and constraints into account, for instance, when introducing lifelong learning and incorporating the use of information and communication technology.

Practical implications

For the implementation of the proposed flexible educational model, it is necessary to change several important conditions that are strongly intertwined with the existing educational system. The organization in study years, study periods and lesson schedules must be replaced by more flexible, demand-driven operational management procedures. Laws and regulations, which directly or indirectly restrict the possible activities of students and teachers, must be changed to enable a more flexible operational approach. Criteria and procedures for the financing of educational institutes and students must be adapted to a customized approach in educational programmes. Students and teachers must be prepared for new roles, tasks and responsibilities. This requires, for instance, a more differentiated approach in teacher training. And last but not least, an educational culture and routine that has developed over many decades must be replaced by a more suitable culture and routine. Several of these conditions are already under heavy pressure for change, driven by contemporary societal developments.
For realizing the changes to conditions, all the important stakeholders must be convinced of the advantages and receive incentives for changing to a new approach. Students can get programmes which are customized to their personal situation and qualities, and may become less dependent on one specific educational institute. Combining study and real work can positively influence their motivation. Teacher roles can be varied according to their personal and professional qualities, and their work may become more attractive by participating in teams set up according to disciplines and coaching orientations. HPE institutes can be freed from the operational restrictions of their standard programmes and variants, if they develop a rich pattern of educational services that can attract more students for lifelong learning. For employers educational institutes can contribute more easily to innovative local and regional social-economic activities. For the Ministry of Education the financing of educational institutes and students can become more cost-effective and the quality of education can be improved by the provision of more adequate incentives for institutes and students.
However, there are also many threats and risks for such a development. Students need to become more responsible for their study programmes and ambitions, which may require additional coaching. Teaching can no longer be built on one standard professional profile, but teachers must develop their own orientation and qualities in close cooperation with other team members and the professional field. Initial standard programmes are no longer the main products of educational institutes; they are expected to develop unique services and to compete with each other for quality. A clear picture of standard programmes and certificates must be replaced by a new coherent qualification system based on well-defined competences. New legislation and procedures are

needed to regulate the existence and functioning of educational institutes. Customized educational services must find a new financial basis, which allows students to combine their study and work under different personal circumstances. These and other transitions will require utmost care for the implementation of a new operational approach. The internal and external validation indicated that the case-study simulation was perceived as valid, and that the flexible educational model was considered as a feasible solution and relevant for the realization of innovations in education. However, as the proof of the pudding is in the eating, it is necessary to actually implement the flexible educational model in one or more HPE institutes, in order to prove that it can work in practice. In order to enable a first implementation, a feasible design must be worked out in much more detail, and in close cooperation with the management of an HPE institute. To prepare for such an implementation, the simulation program developed in our project can be used to study the operational system of several institutes. This will broaden the applicability of the flexible educational model and provide a stronger basis for its implementation.

General conclusion

For this general conclusion, the question must be answered whether the originally stated problem with respect to flexibility in education was solved in the current research project. In our step-by-step approach, it was established that the flexibility of programmes in HPE was low with a strong indication that the operational format was crucial to solve this problem (Chapter 2). The first case study confirmed the expectation that changing the operational format could help to increase the flexibility, and that an integral new approach was needed to reach a more substantial improvement in flexibility (Chapter 3). The second case study indicated that a completely flexible operational format offers a feasible solution for organizing educational programmes in HPE (Chapter 4). Concepts and tools from operations management positively contributed to the analysis, design and testing of solutions for the flexibility problem, in particular by throwing light on formerly unexpected operational solutions, indicating important new directions and tools for developing more flexible educational programmes. From the perspective of educational innovation, this study brought up important new directions and questions which were triggered by the development of a really new, highly flexible operational approach. Features and presumptions that were always beyond discussion were now brought up for debate. Educational experts positively validated the simulation, and valued the model as both a tool and an educational approach; they expressed the opinion that the model could contribute to innovations in education (Chapter 5). But increasing the flexibility of education is an extremely complex issue in a continuously evolving societal setting. Further R&D is needed to continue the elaboration of flexibility problems and promising solutions.

References

Adviesraad voor het Wetenschaps- en Technologiebeleid (1997). *Een werkzaam leven lang leren* [Learning a working-life long]. Den Haag, The Netherlands: Sdu.

Anderson, D. R., Sweeney, D. J., & Williams, T. A. (1994). *An introduction to management science: Quantitative approaches to decision making.* Minneapolis, MI: West Publishing Company.

Adviesraad voor het Wetenschaps- en Technologiebeleid (1997). *Een werkzaam leven lang leren* [Learning a working-life long]. Den Haag, The Netherlands: Sdu.

Baeten, J. J. M. (1998). *Op naar de 21e eeuw. Het nieuwe opleidingsconcept. Voltijd HEAO-opleidingen Bedrijfseconomie, Commerciële economie, Management Economie en Recht van de Hogeschool van Amsterdam* [Towards the 21st century. The new training concept. Full-time programmes in Business economics, Commercial economics, Management economics and law of the Hogeschool of Amsterdam]. Breda, The Netherlands: Citowoz.

Ball, M. O., Datta, A., & Dahl, R. (1992). *Building decision support systems that use operations research models as database applications.* Available: http://www.isr.umd.edu/TechReports/ISR/. Accessed: January 29, 1999.

Banks, J. (1998). *Handbook of simulation: Principles, methodology, advances, applications, and practice.* New York: John Wiley & Sons, Inc.

Bertrand, J. W. M., & Wijngaard, J. (1989). Het organiseren van flexibiliteit, oftewel: wacht u voor wachten. In J. M. W. Geraerds, & M. Igel (Eds.) *Flexibiliteit in logistiek* [Flexibility in logistics] (pp. 56-80). Alphen aan de Rijn, The Netherlands: Samsom.

BETA (1999). *BETA Research programme.* Available: http://www.tue.nl/beta/research/. Accessed: January 25, 1999.

Bologna declaration (1999). *The European higher education area: Joint declaration of the European Ministers of education, convened in Bologna on the 19th of June 1999.* Bologna, Italy: Confederation of EU Rectors' Conferences and Association of European Universities.

Centraal Bureau voor de Statistiek (1998). *Jaarboek onderwijs 1998. Feiten en cijfers bijeengebracht door het CBS* [Yearbook education 1998: Facts and figures collected by the CBS]. Alphen aan de Rijn, The Netherlands: Samsom / H. D. Tjeenk Willink.

Centraal Bureau voor de Statistiek (1999). *StatLine.* Available: http://statline.cbs.nl/, 03-22-1999. Heerlen / Voorburg, The Netherlands: Centraal Bureau voor de Statistiek.

Centraal Bureau voor de Statistiek (2000). *Statistisch Jaarboek 2000* [Statistical Year Book 2000]. The Hague, The Netherlands: Sdu.

Chase, R. B., & Aquilano, N. J. (1989). *Production and operations management: A life cycle approach* (5th ed.). Homewood, IL: Irwin.

Clarke, B., & James, C. (1998). Flexibility in post-registration nurse education in England. *Innovations in Education and Training International, 35*, 292-301.

Collis, B., Vingerhoets, J., & Moonen, J. (1997). Flexibility as a key construct in European training: Experiences from the TeleScopia project. *British Journal of Educational Technology*, 28, 199-218.

Danish Ministry of Education (1994). *Technology-supported learning (Distance learning).* Copenhagen, Denmark: Ministry of Education.

De Vries, G., Bertrand, J. W. M., & Vissers, J. M. H. (1999). *Design requirements for health care production control systems* (research report TUE/TM/LBS/99-01). Eindhoven, The Netherlands: University of Technology / Faculty of Technology Management.

Eurydice - The information network on education in Europe [Internet] (1980). Available: www.eurydice.org. Socrates Program, European Commission, Education and Culture.

Everwijn, S. E. M. (1996). Leerdoelstellingen en de ontwikkeling van competenties: een conceptueel kader. In P. W. J. Schramade (Ed.) *Handboek effectief opleiden* [Handbook effective training] (pp. 65-85). 's-Gravenhage, The Netherlands: DELWEL.

Fitzsimmons, J. A., & Fitzsimmons, M. J. (1994). *Service management for competitive advantage.* New York: MacGraw-Hill,Inc.

Geerligs, J., & Nijhof, W. J. (2002). Design and effects of a flexible VET system: A case study in Dutch agricultural education. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Geraerds, W. M. J., & Igel, M. (Eds.) (1989). *Flexibiliteit in Logistiek* [Flexibility in logistics]. Alphen aan de Rijn, The Netherlands: Samsom Bedrijfsinformatie.

Hall, A. D. (1962). *A methodology for systems engineering.* Princeton, NJ: Van Nostrand.

Haug, G., Kirstein, J., & Knudsen, I. (1999). *Trends in learning structures in higher education.* [Project Report]. Available: http://www.rks.dk/, 31-10-2000. Confederation of European Union Rectors' Conferences / Association of European Universities.

Hermans, L. M. L. H. A. (1998). *Brief* van *de Minister van Onderwijs, Cultuur en Wetenschappen Aan de Voorzitter van de Tweede Kamer der Staten-Generaal* [Letter of the Minister of Education, Culture and Sciences to the Parliament]. (25615 Hoger Onderwijs en onderzoek Plan 1998, nr. 31, 16 oktober 1998). Zoetermeer, The Netherlands: Ministerie van Onderwijs, Cultuur en Wetenschappen.

Hillen, D. W. (1995). *Simulatie in produktie en logistiek* [Simulation in production and logistics]. Schoonhoven, The Netherlands: Academic Service.

Holmes, G., & Hooper, N. (2000). Core competence and education. *Higher Education*, *40*, 247-258.

Hytönen, T., Poell, R., & Chivers, G. (2002). HRD as a professional career? Perspectives from Finland, The Netherlands, and the United Kingdom. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Informatie Beheer Groep (1998). *Instroomwijzer: Aanmelding eerste jaar hogeschool of universiteit, 1999-2000* [Enrollment information: First registration for higher education]. Groningen, The Netherlands: Informatie Beheer Groep [IBG] / Onderwijsdiensten.

Jacobs, P. H. M., Lang, N. A., & Verbraeck, A. (2002). D-SOL; A distributed Java based discrete event simulation architecture. In E. Yücesan, C. H. Chen, J. L. Snowdon, & J. M. Charnes (Eds.) *Proceedings of the 2002 Winter Simulation Conference* [2 volumes] (pp. 793-800). Piscataway, NJ: Institute of Electrical and Electronics Engineers.

Johnston, R. (1999). Beyond flexibility: issues and implications for higher education. *Higher Education Review, 32*, 55-67.

Kelton, W. D., Sadowski, R. P., & Sadowski, D. A. (2002). *Simulation with ARENA*. (2nd ed.). New York: McGraw-Hill.

Kessels, J. W. M. (1993). *Towards design standards for curriculum consistency in corporate education* (dissertation). Enschede, The Netherlands: University of Twente.

Kouwenaar, K., & Stannard, J. (Eds.) (1988). *Higher education in The Netherlands: Characteristics, structure, figures, facts.* The Hague, The Netherlands: NUFFIC / VSNU / HBO-Raad / The Netherlands Ministry of Education and Science.

Krajewski, L. J., & Ritzman, L. P. (1996). *Operations management: Strategy and analysis* (4th ed.). Reading, MA: Addison-Wesley Publishing Company.

Lassnigg, L. (2002). Professionalism as a path for the reform of VET systems. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Law, A. M., & Kelton, W. D. (2000). *Simulation modeling and analysis* (3rd ed.). Boston, MA: McGraw-Hill.

Marhuenda, F. (2002). Resources for flexibility: Critical comments. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Mayer, K. (2002). Vocational education and training in transition: From Fordism to a learning economy. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Medmodel (1999). Available: http://www.medmodel.com/. Accessed: January 29, 1999.

Ministerie van Onderwijs, Cultuur en Wetenschappen (1997). *Ontwerp hoger onderwijs en onderzoek plan 1998* [Concept higher education and research plan 1998]. Zoetermeer, The Netherlands: Ministerie van Onderwijs, Cultuur en Wetenschappen / Directie Voorlichting.

Ministerie van Onderwijs, Cultuur en Wetenschappen (1999). *Hoger onderwijs en onderzoek plan 2000* [Higher education and research plan 2000]. Zoetermeer, The Netherlands: Available: http://www.minocw.nl/hoop2000/nav.htm, 09-21-1999.

Nieuwenhuis, L. F. M. (2002). Learning organisations for VET. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Nieuwenhuis, L. F. M., Nijhof, W. J., & Heikkinen, A. (2002). Shaping conditions for a flexible VET. In W. J. Nijhof, A. Heikkinen, & L. F. M. Nieuwenhuis (Eds.) *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Nijhof, W. J., & Streumer, J. N. (1994). Flexibility in vocational education and training: An introduction. In Nijhof, W. J., & Streumer, J. N. (Eds.) *Flexibility in training and vocational education* (pp. 1-12). Utrecht, The Netherlands: Lemma.

Nijhof, W. J., Heikkinen, A., & Nieuwenhuis, L. F. M. (Eds.) (2002). *Shaping flexibility in vocational education and training.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Pratt, D. (1980). *Curriculum: Design and development.* New York: Harcourt Brace Jovanovich, Inc.

Research Center for Education and the Labour Market (1999). *De arbeidsmarkt naar opleiding en beroep tot 2004* [The labour market by training and profession until 2004]. Maastricht, The Netherlands: Maastricht University / Faculty of Economics and Business administration / Research Center for Education and the Labour Market [ROA].

Schellekens, A. M. H. C., Nagtegaal, C., Schlusmans, K., & Kinkhorst, G. (1997). *BI / LE en Competentieleren. De opvattingen van docenten en studenten over de opleidingen BI en LE en de introductie van competentieleren* [BI / LE and competence-based learning. Opinions of tutors and students on the programmes BI and LE and the introduction of competence-based learning]. Heerlen, The Netherlands: Open Universiteit Nederland.

Schellekens, A. M. H. C. (1998). De organisatie van competentiegericht onderwijs. Aanzetten voor een nieuw ontwerp van de BI/LE-opleiding. In K. Schlusmans, C. Nagtegaal, G. Kinkhorst, P. van de Aa, W. Verreck, A. M. H. C. Schellekens, & P. van Vilsteren (Eds.) *Competentiegericht leren. Een bundeling van artikelen en instrumenten voor het ontwerpen en ontwikkelen van competentiegericht leren* [Competence-based learning. A collection of articles and tools to design and develop competence-based learning]. Heerlen, The Netherlands: Open Universiteit Nederland / OTEC.

Schellekens, A., Paas, F., & Van Merriënboer, J. J. G. (2003). Flexibility in higher professional education: A survey in business administration programmes in The Netherlands. *Higher Education, 45*, 281-305.

Schellekens, A., Paas, F., Verbraeck, A., & Van Merriënboer, J. J. G. (2003). *Flexible programmes in higher professional education: An operations management approach.* Manuscript submitted for publication.

Schellekens, A., Paas, F., Verbraeck, A., & Van Merriënboer, J. J. G. (2004). *Designing flexible programmes in higher professional education by means of simulation modeling.* Manuscript submitted for publication.

Schellekens, A., Paas, F., & Van Merriënboer, J. J. G. (2004). *Expert validation of a flexible educational model for higher professional education.* Manuscript submitted for publication.

Schlusmans, K., Kinkhorst, G., Nagtegaal, C., Van Vilsteren, P., & Schellekens, A. M. H. C. (1998). Competentiegericht leren als onderwijsconcept voor de Faculteit Economie en Management van de Hogeschool van Utrecht. In K. Schlusmans, C. Nagtegaal, G. Kinkhorst, P. van de Aa, W. Verreck, A. M. H. C. Schellekens, & P. van Vilsteren (Eds.) *Competentiegericht leren. Een bundeling van artikelen en instrumenten voor het ontwerpen en ontwikkelen van competentiegericht leren.* [Competence-based learning. A collection of articles and tools to design and develop competence-based learning] (pp. 1-7). Heerlen, The Netherlands: Open Universiteit Nederland.

Shah, C., & Burke, G. (1999). An undergraduate student flow model: Australian higher education. *Higher Education, 37*, 359-375.

Sorbonne declaration (1998). *Joint declaration on harmonisation of the architecture of the European higher education system by the four Ministers in charge for France, Germany, Italy and the United Kingdom.* Paris, France: Confederation of EU Rectors' Conferences and Association of European Universities.

Starr, M. K. (1989). *Managing production and operations.* Englewood Cliffs, NJ: Prentice Hall International, Inc.

Van den Berg, E. (1996). *Naar flexibel onderwijs. Handboek schoolorganisatie en onderwijsmanagement* [Handbook school organization and educational management.] (Pt B1410, p. 1-16). Alphen aan de Rijn, The Netherlands: Samsom / H. D. Tjeenk Willink.

Van den Born, P. (1997). *Flexibele organisatie van het opleidingsaanbod* [Flexible organization of educational programmes]. 's Hertogenbosch, The Netherlands: BVE-Raad / CINOP.

Van Meel, R. M. (1992). *Perspectives on organization and management of higher education* [OTIC Research report 49]. Heerlen, The Netherlands: Open Universiteit Nederland.

Van Meel, R. M. (1997). *Management of flexible responses in higher education* (dissertation). Utrecht, The Netherlands: Lemma.

Van Merriënboer, J. J. G., (1997). *Training* complex *cognitive skills: A four-component instructional-design model for technical training.* Englewood Cliffs, NJ: Educational Technology Publications.

Verbraeck, A. (1991). *Developing an adaptive scheduling support environment.* (dissertation). Delft, The Netherlands: Delft Technical University.

Vissers, J. M. H. (1994). *Patient flow based allocation of hospital resources* (dissertation). Eindhoven, The Netherlands: University of Technology.

Waters, D. (1996). *Operations management. Producing goods and services.* Reading, MA: Addison-Wesley Publishing Company.

Weiss, H. J., & Gershon, M. E. (1989). *Production and operations management.* Boston, MA: Allyn and Bacon, Inc.

Wesson, D. A. (1995). The interactive effects of rules on teaching timetable flexibility and resource utilization. *Higher Education, 30*, 305-312.

Abbreviations

4C/ID-model	Four-component instructional-design model
AC	Accountancy
BA	Business administration *Bedrijfskunde*[1]
BE	Business economics *Bedrijfseconomie*
BI	Business informatics *Bedrijfskundige informatica*
CBS	Centraal bureau voor de statistiek
CE	Commercial economics *Commerciële economie*
CP variant	Class-programme variant
D-SOL	D-SOL
fte	full-time equivalent
HAVO	*Hoger algemeen voortgezet onderwijs*
HBO	*Hoger beroepsonderwijs*
HPE	higher professional education *hoger beroepsonderwijs*
ICT	information and communication technology *informatie- en communicatietechnologie*
IL	International business and languages
IP variant	Individual-programme variant
MBO	*Middelbaar beroepsonderwijs*
M	Mean
MinOCW	*Ministerie van onderwijs, cultuur en wetenschappen*
MR	Management, economics & law *Management, economie & recht*
R&D	Research and Development
sc	Study credit *Studiepunt*
SD	Standard deviation
VET	Vocational education and training *Beroepsonderwijs en opleiding*
VWO	*Voorbereidend wetenschappelijk onderwijs*

[1] Dutch names in *italics.*

Summary

**Towards flexible programmes in higher professional education:
An operations-management approach**

In The Netherlands, flexibility is a topic of current interest in the field of higher professional education (HPE). Increasing the flexibility in education is considered a main priority in Dutch HPE policies, for instance, to customize educational programmes to the needs of students, to enable competence-based education, to facilitate lifelong learning, and to promote students to do part of their study in other countries.
In this dissertation, the focus is on the operational aspect of flexibility. Flexibility in education is primarily considered with the issue to what extent educational institutes can offer students an educational programme that fits their individual needs and circumstances. Operational flexibility concerns the operational characteristics, which determine how programmes in educational institutes are organized in order to support the learning of the students in an adaptive way. Although the specific learning processes of individual students, as well as social, psychological, didactic, economic and other aspects can definitely be considered of importance for implementing flexible solutions in education, they are not explicitly taken into account in the current study.
At the start of this study, operational flexibility was defined in terms of characteristics related to four aspects of educational systems: the (1) curriculum, (2) activities, (3) facilities, and (4) environment. The curriculum determines the goals, content and approach of educational programmes. The activities determine how educational programmes are organized, planned and executed. The facilities concern the availability of personnel and material resources. The environment represents the needs for education of students and employers, and the position, the legislation and the financial means for educational institutes.
From our survey among HPE institutes in The Netherlands (Chapter 2), it became clear that the operational flexibility of educational programmes in departments for Business Administration (BA) is very low. The operational characteristics indicated that the educational programmes had a stereotyped operational format, with a strong negative impact on their flexibility. An operations-management approach was proposed to find out how the flexibility could best be increased.
An operations management framework was used to position educational institutes at the levels of strategic management, operational design, and process management. At the strategic management level, educational institutes can best be seen as service organizations. Educational programmes can be considered as services which must be customized to the educational needs of the individual students. At the operational-design level, this requires a process-focused strategy instead of the present product-focused strategy, in which educational programmes are supplied without taking into account the specific needs of the students. At the level of process management, customer

involvement and resource flexibility appeared to be important characteristics for a more flexible organization of educational programmes.
Changing the operational format of educational programmes requires a reconsideration of the educational approach of educational institutes. A competence-based approach was considered suitable for redesigning the curriculum to increase the flexibility of educational programmes. Design principles from the Four-component instructional-design (4C/ID) model were used to determine three kinds of activities in educational programmes: task-directed, knowledge-directed and skill-directed activities.
Task-directed activities can be implemented in projects or real work (e.g., internships or jobs), in which students work on tasks in order to develop their competences. The necessary knowledge and skills can be acquired in courses and other comparable activities when they are needed to support the learning and development of the students. For implementing these activities additional contributions are expected from the field of educational technology.
Introducing a new operational format in educational programmes appeared to be a major enterprise that could not be actually implemented in an existing educational institute without far-reaching practical consequences. Therefore, discrete-event computer simulation was chosen as a tool to develop and test new designs for increasing the operational flexibility of educational programmes. Data of a real educational institute were used in the simulations for redesigning the curriculum and educational programmes - ensuring a high similarity between the simulation model and educational reality. The simulations of the resulting more flexible solutions were also validated and evaluated by representatives of the educational institutes.
From the flexible models of the case studies, a generic flexible educational model was derived. In this flexible educational model, each student has his or her own customized programme that is stored in a personal dossier. Programmes are no longer organized in study years, study periods and lesson schedules. Students are no longer organized in programme-based cohort groups. A student can start a programme in any week of a year and vary at his or her own discretion the proportion of hours spent on study and work, making the distinction between full-time and part-time programme variants unnecessary. Task-directed activities in projects or internships, which are intensively coached by dedicated members of the teaching staff, constitute a customizable core programme aiming at competence development for each student. Knowledge- and skill-directed activities are organized in courses, in which students can participate when needed in order to prepare and support their task-directed activities. The teaching staff is organized in professional and discipline-oriented teams, which are responsible for the coaching and organization of the task-directed activities and for providing the courses which are needed by the students. Depending on their capabilities and available study time, students can complete a programme without loosing time unnecessarily. In the simulated flexible educational model, for instance, 33.5 percent of the students completed a study programme of nominal four years of study in two-and-a-half to four years. The generic flexible educational model was positively validated and evaluated by educational experts.
The flexible educational model is intended to contribute to increasing the flexibility of education and to create important operational conditions for innovations in education.

A next step for further research is to apply the model by means of simulation in a larger number of institutes in order to broaden the basis and to gather further evidence for the usability of the model. To prove its practical viability, the model needs to be actually applied in an educational institute on the basis of a detailed plan which needs to be developed and implemented in close cooperation with the management.
The research project used concepts and tools from the field of operations management to increase the flexibility of educational programmes. In a step-by-step approach, a survey, two case studies, and an expert validation were carried out to develop a flexible educational model. The Chapters 2 to 5 of this dissertation reflect those steps and present the related studies, starting with a General Introduction in Chapter 1, and ending with a General Discussion in Chapter 6.

In *Chapter 1*, the research project is introduced. Innovative developments in HPE are considered with respect to their effects on flexibility, and with respect to their requirements for flexibility in education. In a first analysis, flexibility is determined as an operational issue that characterizes educational programmes. As flexibility of operations is an object of study in operations management, a research approach combining operations management and educational technology is proposed in order to contribute to increasing the flexibility of educational programmes.

In *Chapter 2*, a survey among BA programmes in HPE institutes in The Netherlands is described. A conceptual framework was developed for determining the operational characteristics of HPE programmes in The Netherlands and how flexible they are. The survey results indicate that the flexibility is low, in particular with respect to operational characteristics. It was found that the BA programmes had a stereotyped operational format, which restricted their flexibility regardless of the different programme variants. It was established that the scope of the study had to be broadened from single programmes to programme clusters offered by departments of HPE institutes.

In *Chapter 3*, the first case study in an HPE institute is described, in which a partial flexible model was developed. To prepare this study, it was considered how operations management can help to investigate the operational flexibility of educational programmes. An operations-management framework was used to position educational institutes as service organizations, indicating that a process-focused approach would be most appropriate to serve students according to their individual needs. To find out whether a process-focused approach could increase the flexibility of educational programmes, the curriculum was modified by separating the courses for acquiring instrumental or supportive skills. Real data of the case study institute were used for conducting a discrete-event simulation experiment, in which the new design was compared with the existing situation. In line with our expectations, the effects of this curriculum modification on flexibility were found to be positive. But the increase in flexibility in the simulation was quite restricted, due to the still persisting format of fixed study years and standard study periods. Although simulation proved to be a useful tool, it also became clear that the simulations needed more detailed modeling.

In *Chapter 4*, the second case study is described in which an integral flexible model was developed. For this purpose, an entirely demand-oriented and process-focused operational approach was developed and applied in a simulation. Taking into account a set of operational characteristics for flexible programmes, the curriculum and programmes were redesigned according to principles derived from the 4C/ID model. The validation results indicated that this integral 'flexibility-by-design' approach offered an operationally attainable flexible solution for organizing educational programmes, which, as concluded, would require additional Research & Development to be put into practice. More detailed simulation modeling appeared to put higher demands on the software tools, which resulted in the adoption of a more advanced, object-oriented development system.

In *Chapter 5*, an expert validation of the flexible educational model is described. The development from the common educational model towards a flexible educational model was traced with respect to the main operational characteristics. On the basis of the integral flexible model of Chapter 4, a generic flexible educational model was now conceived by disregarding the specific goals and operational constraints of the case setting. In addition, a study on current developments in the field of vocational education and training in Europe was used to position the generic flexible educational model in the context of innovation. Experts in the field of higher education considered the simulation as a valid representation of HPE institutes in The Netherlands and evaluated the generic model as a feasible and useful contribution for increasing the flexibility of educational programmes. The model was also characterized as desirable and innovative. In addition, the simulation program was appreciated as an important tool for gaining insight in the operational aspects of educational programmes.

In *Chapter 6*, the steps of the research approach are briefly resumed and reviewed with respect to the concept of flexibility, the contributions of operations management and instructional design, and educational innovation. The use of the generic flexible model is discussed. Theoretical implications are considered for educational innovations and educational design. Directions for future Research & Development are recommended. Practical consequences and risks for implementation of a flexible approach are considered. Finally, general conclusions are drawn about the contribution of this research project to solve the flexibility problem in HPE.