Informatics Curriculum Framework 2000

for Higher Education

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IFIP

International Federation for Information processing (IFIP)

ICF-2000

IFIP/UNESCO Informatics Curriculum Framework 2000

BUILDING EFFECTIVE

HIGHER EDUCATION

INFORMATICS CURRICULA

IN A SITUATION OF CHANGE

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The International Federation for Information Processing (IFIP) has been requested by UNESCO to carry out this project under the title 'Modular training programme'. IFIP's Technical Committee 3 (on Education) has adopted the project. It is co-ordinated by the Chair of TC3 and has been executed by members of Working Group 3.2 (on Higher Education), complemented with input from other IFIP Technical Committees.

Management summary

COPING WITH CHANGE

Informatics is a new discipline. As a result informatics education is in a situation of constant topical and organisational change. What may start as just a credit course in informatics may well develop into a Minor or a Major informatics programme. What a few enthusiasts originally teach, may later require a staff formally educated in informatics.
These rapid developments are difficult to manage for Ministries of Education and educational managers. And also publishers and teaching staff are confronted with a situation of constant change. The Informatics Curriculum Framework 2000 (ICF-2000) has been designed to help cope with these developments and situations of change: ICF-2000 offers a framework for controlled topical and organisational change. It helps Ministries of Education to develop a systematic and controlled higher education informatics policy. It helps institutions to systematically and effectively develop their educational informatics programmes, if need be from scratch. Because of the fact that ICF-2000 graduate profiles build one upon the other earlier investments keep their value when a programme is extended.

A STATE-OF-THE-ART CURRICULUM

IFIP/UNESCO ICF-2000 specifies a state-of-the-art informatics curriculum framework. IFIP TC3 strongly feels that only the state-of-the-art will do. This offers to institutions and countries where informatics education is still developing, the foundations from which to leapfrog to the front of developments. It is no use to fully repeat the development process with respect to informatics education that has already taken place elsewhere. This will only slow down developments and keep institutions and countries from closing the gap. Many opportunities arise from the field of informatics and its resulting technologies. This curriculum framework attempts to facilitate fruitful use of these opportunities.

ECONOMIC DEVELOPMENT

Informatics plays an important part in the economic processes of today. Many professionals are needed with an informatics background. However, depending on their specific roles in the economic process, these professionals have specific informatics needs. ICF-2000 offers 8 different curriculum specifications that fit 8 professional role categories. By selecting the appropriate future professional role of the students of today an effective and efficient higher education curriculum can be constructed [Quick access, Section 0]. Alternatively, professionals of today can be brought up to date in an effective and efficient way fitting their professional role.

LOCAL CIRCUMSTANCES

Circumstances are different between countries and between institutions within a country. Implementation factors have therefore to be taken into account when designing a higher education informatics curriculum. ICF-2000 offers to countries and educational institutions a development framework linked with these implementation factors (Quick access, Section 0). This framework ensures that the minimal conditions for a specific curriculum implementation are met and furthermore allows systematic and controlled further development.

RATIONALE BEHIND ICF-2000

ICF-2000 is offering an informatics curriculum framework, from which various curriculum implementations can be constructed in a straightforward way. These implementations are strongly influenced by cultural, societal and institutional factors. Institutions and countries will be able to construct a modern curriculum from this framework in an implementation process in which specific needs, restrictions (for example with respect to resources) and possibilities can be taken into account.

Such a curriculum can also easily be extended with no consequence for the curriculum already in use: the ICF-2000 graduate profiles build upon each other.
ICF-2000 allows higher education publishers to produce learning materials in the cultural traditions of their country. Alternatively, popular high quality learning materials from developed countries may be used. This two-fold approach is supported by the many so-called source links in ICF-2000 to other prominent and current informatics curricula from leading professional informatics societies.
This mechanism also ensures that ICF-2000 can be easily kept up to date. Whenever these professional informatics bodies publish an updated curriculum, such an update can be easily included in ICF-2000. Thus durable access to the state of the art in informatics education is provided. The coverage of ICF-2000 can be judged by its mapping through specific source links on two current informatics classification systems that are both frequently updated.

TERMINOLOGY

There is a continuing discussion about the best term to be used for the broad area as addressed in the IFIP/UNESCO project. Staying away from this discussion, we adopt the term ‘informatics’ (or its abbreviation by the letter ‘I’), just for convenience. This term has its significance mainly in the European tradition. However, within the IFIP/UNESCO project it is intended to be nothing more than an ‘umbrella’ label. Hence, ‘informatics’ or ‘I’ refers to a diverse, yet related family of domains, including ‘computing’, ‘computer science’, ‘computer engineering’, ‘information systems’, ‘management information systems’, ‘computer information systems’, ‘software engineering’, ‘artificial intelligence’ or ‘AI’, ‘information technology’ or ‘IT’, ‘information and communication technology’ or ‘ICT’, and so on.

QUICK ACCESS TO ICF-2000

Construction of a state of the art higher education informatics curriculum with ICF-2000 is straightforward. One just needs to follow the steps outlined in Section 0 (Quick access). In the first step the educational need is identified on the basis of the need for informatics educated professionals in the local economy. These professionals fall into different categories and each category is linked to a specific ICF-2000 graduate profile. In the next step the educational possibilities are identified within the context of the particular circumstances of country and institution. In a next step needs and possibilities are brought into balance. In the third extraction step curriculum unit descriptions are produced using the resources of worldwide-accepted informatics curricula. These descriptions may be produced in the own language and in such a way that these fit the local cultural and educational setting. And in the last step the curriculum is realised using widely available learning materials linked with these worldwide-accepted curricula.

KEEPING ICF-2000 UP TO DATE

Developments in the field of informatics are very fast. The content of informatics education is changing continuously. This means that curricula and study materials have to be updated all the time. ICF-2000 is a framework that refers to major widely accepted and widely implemented informatics curricula and associated resources. Much effort is put into keeping these curricula up to date. For example, the ACM/IEEE-CS Computing Curriculum '91 is currently under revision. The revised curriculum is expected in 2001. To keep ICF-2000 up to date with this development the appendix describing ACM curriculum '91 has to be updated to describe ACM/IEEE-CS Curriculum 2001. In ICF-2000 itself only the references to this appendix have to be updated. In this way ICF-2000 can be kept up to date with relatively little effort. Also new curricula, for example the IEEE-CS and ACM curriculum for software engineering, may be added. An updating mechanism is proposed [Keeping ICF-2000 up to date, section 13].

Acknowledgement of sources

ICF-2000 is linked to the results of other curricular efforts, undertaken by professional organisations such as ACM, IEEE, AITP and AIS. Thus convenient access is realised to a rich source of information and a variety of high quality bodies of knowledge.
The ACM Computing Classification System is used as a reference for the contents of ICF-2000. The Unified Classification Scheme for Informatics (UCSI), a recently developed synthesis of various body of knowledge schemes from ACM, IEEE, AITP and IFIP, is used for a similar purpose.
Below we pay tribute to the work of our colleagues and sister organisations. Their efforts are acknowledged in alphabetical order (including web site URLs – if available).

ACM
The ACM Computing Classification System [1998 Version]
http://www.acm.org/class/1998/homepage.html

ACM / AIS / AITP (formerly DPMA)
IS'97: Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems
http://www.acm.org/education/curricula.html#IS97
http://aisnet.org/reso.shtml

ACM / IEEE-CS
Computing Curricula 1991: Report of the ACM/IEEE-CS Joint Curriculum Task Force
http://www.acm.org/education/curr91/homepage.html
http://www.computer.org/educate/cc1991

ACM-SIGCHI
Curricula for Human-Computer Interaction [1992]
http://www.acm.org/sigchi/cdg/

ECDL Foundation
The European Computer Driving Licence standard of competence [since 1997]
(the ECDL is an internationally recognised standard of competence certifying that the holder has the knowledge and skills needed to use the most common computer applications efficiently and productively)
http://www.ecdl.com/

ISCC'99: An Information Systems-Centric Curriculum '99. Program Guidelines for Educating the Next Generation of Information Systems Specialists, in Collaboration with Industry
(supported by the National Science Foundation grants DUE/CIS-9352944, DUE-9455450 and DUE-9796243)
Draft report (January 1999), endorsement sought by **ACM, AIS** and **IEEE-CS**, no web site found (see also reference [2] at the end of the document).

UCSI: Unified Classification Scheme for Informatics [release 1.2, 1997]
(this system has been presented and utilised at a Working Conference organised in 1997 by IFIP Working Group 3.2 on the theme 'Informatics (computer science) as a discipline and in other disciplines: what is in common?'; see reference [3] at the end of the document)
No web site available.

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The Informatics Curriculum Framework 2000 [ICF-2000]

0 Quick access to IFC-2000

This Section allows Ministries of Education, educational managers, curriculum developers, developers of learning materials and teaching staff quick access to the ICF-2000 resources.

ICF-2000 is a ‘curriculum framework’ from which government authorities, industry, business and educational institutions may extract their own curriculum in terms of knowledge & skills units. This curriculum can be so designed as to achieve a best-fit implementation in the specific cultural, developmental and economical setting. Because of the fact that ICF-2000 refers to widely accepted curricular descriptions, the extracted curriculum can be realised taking advantage of widely available learning materials.

EXTRACTION STEPS

Step 1	Selection of curriculum specifications fitting the target category of professionals;
Step 2	Selection of graduate profiles from ICF-2000 fitting the educational environment;
	Balancing the results of Step 1 with the results of Step 2;
Step 3	Producing unit descriptions using world-wide accepted informatics curricula that fit selected curriculum specifications;
	Realisation of extracted curriculum units using widely available learning materials.

EXTRACTION STEP 1 SELECTION OF CURRICULUM SPECIFICATIONS FITTING THE TARGET CATEGORY OF PROFESSIONALS

Professional Categories (Section 4)
Higher education aims to educate the professionals of tomorrow. Their future professional role decides which informatics knowledge is needed. ICF-2000 distinguishes between three main categories of professionals, acting or interacting with informatics in a broad sense:

A I-user
Non-I-professionals using ready made I-technology or I-applications in their work, for example non-informatics professionals using I-applications like text processors or I-technology like digital communication systems (many of the professionals in highly developed economies are I-users today);

B I-appliers:
Non-I-professionals applying I-knowledge and I-skills in areas different from informatics, for example non-informatics professionals in the economic field who use I-applications to model economic situations;

C I-workers:
I-professionals working in the field of informatics, for example the system engineer who, as informatics professional, develops I-applications or I-technology (note that the field of informatics is broad with diffuse boundaries with other disciplines).

It is important to note that I-appliers and I-workers generally will also be I-users, while I-workers may or may not be I-appliers too.
Further note that ICF-2000 deals with university and higher professional education. Lower level education programs are not considered. A description of a curriculum framework for secondary education in developing countries can be found in the UNESCO/IFIP curriculum 'Informatics for Secondary Education, A Curriculum for Schools' [5].

ICF-2000 recognises 8 different professional categories (Section 4) and 4 different graduate profiles to efficiently satisfy the educational needs of these professional categories. The size of the graduate profiles is 'measured' in terms of credit points: 1 credit point, equals one working day (= about 8 hours of study).

A I-users

Category of professionals	**A1**	**INSTRUMENTAL I-USERS**	[Section 4]
Graduate profile	BIP	Basic Instrumental I-Profile	[Section 9]
Size of educational program	20 16 4	credit points (total) credit points (generic) credit points (specific)	
Prerequisites	none		

B I-appliers

Category of professionals	**B1**	**CONCEPTUAL I-APPLIERS**	[Section 4]
Graduate profile	BCP	Basic Conceptual I-Profile	[Section 10]
Size of educational program	40	credit points (total)	
	32	credit points (generic)	
	8	credit points (specific)	
Prerequisites	BIP		

Categories of professionals	**B2**	**INTERFACING I-APPLIERS**	[Section 4]
	B3	**RESEARCHING I-APPLIERS**	[Section 4]
	B4	**DIRECTING I-APPLIERS**	[Section 4]
Graduate profile	MIP	MInor I-Profile	[Section 11]
Size of educational program	80	credit points (total)	
	64	credit points (generic)	
	16	credit points (specific)	
Prerequisites	BIP, BCP		

C I-workers

Categories of professionals	**C1**	**OPERATIONAL I-WORKERS**	[Section 4]
	C2	**ENGINEERING I-WORKERS**	[Section 4]
	C3	**RESEARCHING I-WORKERS**	[Section 4]
Graduate profile	MAP	MAjor I-Profile	[Section 12]
Size of educational program	160	credit points (total)	
	128	credit points (generic)	
	32	credit points (specific)	
Prerequisites	BIP, BCP, MIP		

Curriculum specifications adapted to specific professional categories
Depending on their specific future professional role students have different educational needs. ICF-2000 takes account of these needs by defining 4 different graduate profiles:

- BIP, Basic Instrumental I-Profile [Section 9];
- BCP, Basic Conceptual I-Profile [Section 10];
- MIP, MInor I-Profile [Section 11];
- MAP, MAjor I-Profile [Section 12].

Because the graduate profiles build one upon the other an efficient curriculum structure results.

However, professional categories B2, B3 and B4 have characteristics that should lead to differences within the identified graduate profile MIP. And professional categories C1, C2 and C3 have characteristics that should lead to differences within the identified graduate profile MAP. These differences concern:

- The coverage of informatics themes [Section 6];
- The orientation in terms of goals and competencies to be reached [Section 8].

A curriculum specification is therefore given that 'fingerprints' a graduate profile for the specific professional category with respect to:

- Themes
  1 Representation of information;
  2 Formalism in information processing;
  3 Information modelling;
  4 Algorithmics;
  5 System design;
  6 Software development;
  7 Potentials and limitations of computing and related technologies;
  8 Computer systems and architectures;
  9 Computer-based communication;
  10 Social and ethical implications;
  11 Personal and interpersonal skills;
  12 Broader perspectives and context (including links with other disciplines).

and:

- Orientations

AW	*AWareness (know or use):* Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages;
AP	*APplication:* Aiming at developing a basic conceptual understanding of informatics and of some more advanced informatics skills which allow students to apply basic informatics to other disciplines or areas;
DM	*Design and Modelling:* Aiming at developing a general understanding and broad overview of informatics, especially with respect to the modelling and the design of informatics applications;
CA	*Conceptualisation and Abstraction:* Aiming at developing a thorough understanding of and well-developed skills in informatics as a broad discipline, the essence being to further develop the capability of students to abstract and to conceptualise.

Example of a curriculum specification

Curriculum specification of BIP

Graduate I-profile	**BIP**	**BASIC INSTRUMENTAL I-PROFILE**															
Categories of professionals	A1	Instrumental I-users															
		credit points (total)		credit points (generic)			credit points (discipline specific)										
Size of educational program	***BIP***	***20***		***16***			***4***										
Prerequisites	none																
Constituting units			*size*	*orien-*	---------- *themes* ----------												
code	*title*		*[cp]*	*tation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	
[--- generic ---]																	
BIP-01	Context for informatics applications [1]		3-5	AW	x		x		x		x	x	x	x		x	
BIP-02	Hands-on with software packages [1]		3-5	AW	x		x	x			x	x			x		
BIP-03	Hands-on with software packages [2]		3-5	AW	x		x	x			x	x			x		
BIP-04	Hands-on with networking [1]		3-5	AW	x						x		x		x		
[--- discipline(X) specific --- X may be I ---]																	
BIP/X-01	Operating software in area X [1]		4	AW							x				x	x	
	Total size & theme 'fingerprint'		**20**	**AW**	**4**		**3**	**2**	**1**		**5**	**3**	**2**	**1**	**4**	**2**	

1 credit point (cp) = 1 day of study

Orientation:

AW *AWareness (know or use):*
Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages.

Themes

1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;
8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

For the 'fingerprints' of professional category B1 see Basic Conceptual I-profile [Section 10].

For the 'fingerprints' of professional categories B2, B3 and B4 see MInor I-Profile [Section 11].

For the 'fingerprints' of professional categories C1, C2 and C3 see MAjor I-Profile [Section 12].

Summary
Extraction Step 1: Identifying the needs

Higher education aims to educate the professionals of tomorrow. The future professional role decides which informatics knowledge is needed by the student.

ICF-2000 allows to make a distinction between 8 different professional categories [Section 4]:

1 A1 Instrumental I-users
2 B1 Conceptual I-appliers
3 B2 Interfacing I-appliers
4 B3 Researching I-appliers
5 B4 Directing I-appliers
6 C1 Operational I-workers
7 C2 Engineering I-workers
8 C3 Researching I-workers

Four graduate profiles cover the educational informatics needs of these professional categories:

1	A1	BIP, Basic Instrumental I-Profile	[Section 9];
2	B1	BCP, Basic Conceptual I-Profile	[Section 10];
3	B2, B3, B4	MIP, MInor I-Profile	[Section 11];
4	C1, C2, C4	MAP, MAjor I-Profile	[Section 12].

The graduate profiles are 'fingerprinted' with respect to themes covered and competencies aimed at.

The first extraction step results in the identification of one or more of these fingerprinted curriculumspecifications that suit the local need for informatics professionals.

EXTRACTION STEP 2 SELECTION OF GRADUATE PROFILES FITTING THE EDUCATIONAL ENVIRONMENT

ICF-2000 offers a considerable degree of freedom in the implementation of an actual curriculum in specific cultural and societal settings that are influenced by numerous implementation factors [Section 7]. Here we restrict ourselves to the most important factors in the educational environment. The context is that of higher education institutions where Major and Minor degrees in disciplines other than informatics are awarded.

ICF-2000 offers 4 different graduate profiles:

- BIP, Basic Instrumental I-Profile [Section 9];
- BCP, Basic Conceptual I-Profile [Section 10];
- MIP, MInor I-Profile [Section 11];
- MAP, MAjor I-Profile [Section 12].

Each graduate profile makes demands on specific resources in the educational institution. In this extraction step those profiles are identified that fit the local circumstances. From this starting point educational institutions may develop informatics curricula in a gradual and efficient way, both in terms of resources and personnel. This is facilitated by the fact that ICF-2000 graduate profiles build upon each other.

The educational institution is small

Institutional characteristics	***Choose as option***
There is some, not very advanced, hardware and software Several staff members have pioneered in using computers No staff has graduated in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] No Minor or Major programme in informatics
There is some, not very advanced, hardware and software Several staff members have a Minor in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10] No Minor or Major programme in informatics

The educational institution is small; it specialises in informatics and has an informatics department

Institutional characteristics	***Choose as option***
There is more hardware and software of good quality There is an ICT-support centre Several staff members in the informatics department and in the other departments have a Minor in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10]
There is more hardware and software of good quality There is an ICT-support centre At least some staff members in the informatics department have a Major in informatics	Additionally the informatics department offers a Minor programme in informatics: MINOR I-PROFILE (MIP) [Section 11] No Major programme in informatics

The educational institution is of intermediate size

Institutional characteristics	***Choose as option***
There is some, not very advanced, hardware and software Several staff members have pioneered in using computers No staff has graduated in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] No Minor or Major programme in informatics
There is some, not very advanced, hardware and software Several staff members have a Minor in informatics	Minor or Major in other discipline including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10] No Minor or Major programme in informatics

The educational institution is of intermediate size; it has an informatics department

Institutional characteristics	***Choose as option***
There is more hardware and software of good quality There is an ICT-support centre Several staff members in other departments than informatics have a Minor in informatics	Minor or Major in other discipline than infomatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10]
There is more hardware and software of good quality There is an ICT-support centre At least some staff members in the informatics department have a Major in informatics; the other staff members in the department have a Minor in informatics	Additionally the informatics department offers a Minor programme in informatics: MINOR I-PROFILE (MIP) [Section 11] No Major programme in informatics

The educational institution is large

Institutional characteristics	***Choose as option***
There is some, not very advanced, hardware and software Several staff members have pioneered in using computers No staff has graduated in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] No Minor or Major programme in informatics
There is some, not very advanced, hardware and software Several staff members have a Minor in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10] No Minor or Major programme in informatics

The educational institution is large; it has an informatics department

Institutional characteristics	***Choose as option***
There is more hardware and software of good quality There is an ICT-support centre Several staff members in other departments than informatics have a Minor in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10] No Minor or Major programme in informatics
There is more hardware and software of good quality There is an ICT-support centre At least some staff members in the informatics department have a Major in informatics; the other staff members in the department have a Minor in informatics	Additionally the informatics department offers a Minor programme in informatics: MINOR I-PROFILE (MIP) [Section 11] No Major programme in informatics

The educational institution is large; it has a further developed informatics department

Institutional characteristics	***Choose as option***
There is a good quantity of hardware and software of good quality There is an ICT-support centre Several staff members in the other departments have a Minor in informatics	Minor or Major in other discipline than informatics including: BASIC INSTRUMENTAL I-PROFILE (BIP) [Section 9] BASIC CONCEPTUAL I-PROFILE (BCP) [Section 10] No Minor or Major programme in informatics
There is a good quantity of hardware and software of good quality There is an ICT-support centre Most staff members in the informatics department have a Major in informatics; the other staff members in the department have a Minor in informatics	Additionally the informatics department offers both a Minor and a Major programme in informatics: MINOR I-PROFILE (MIP) [Section 11] MAJOR I-PROFILE (MAP) [Section 12]

Summary
Extraction Step 2: Identifying the possibilities

Implementation of an actual informatics curriculum in specific cultural and societal settings is influenced by numerous implementation factors [Section 7]. On the basis of the most important resource factors in the higher education institution where Major and Minor degrees in disciplines other than informatics are awarded, a selection is made out of 4 graduate profiles:

- BIP, Basic Instrumental I-Profile [Section 9];
- BCP, Basic Conceptual I-Profile [Section 10];
- MIP, MInor I-Profile [Section 11];
- MAP, MAjor I-Profile [Section 12].

In the second extraction step graduate profiles are identified that suit the local resources of an educational institution.

BALANCING THE RESULTS OF STEP 1 WITH THE RESULTS OF STEP 2

Professionals are needed in the society in which educational institutions operate; the future professional role of students decides which informatics knowledge is needed. This educational need can be identified (Extraction Step 1).
On the other hand important resource factors in the situation of an educational institution (or a country) will decide which graduate profile may be delivered within the local boundary conditions (Extraction Step 2).

There may be a mismatch between what is needed (considering the needs of the local economy, Step 1) and what is possible (considering the situation of the educational institution, Step 2). One way or another such a mismatch must be resolved. Either new resources have to be allocated to the educational institution to meet the requirements of the graduate profile to be offered or particular categories of professionals have to be educated elsewhere or brought in from elsewhere.

In a case where the resources of an institution are not sufficient to offer the one profile, another – less demanding profile – may be offered. Once the situation has changed the educational offer can be easily extended to this more demanding profile. This can be done without consequences for the initial profile that was offered, as ICF-2000 graduate profiles build one upon the other.

Summary
Balancing needs and possibilities

There may be a mismatch between what is needed (considering the needs of the local economy, Extraction Step 1) and what is possible (considering the resource situation of the educational institution, Extraction Step 2).

One way or another such a mismatch must be resolved. Either new resources have to be allocated to the educational institution to meet the requirements of the graduate profile to be offered or particular categories of professionals have to be educated elsewhere or brought in from elsewhere.

In a case where the resources of an institution are not sufficient to offer the one graduate profile, another – less demanding profile – may be offered. Because ICF-2000 graduate profiles build one upon the other, the educational offer can be easily extended once the resource situation has changed.

EXTRACTION STEP 3 PRODUCING UNIT DESCRIPTIONS USING WORLD WIDE ACCEPTED INFORMATICS CURRICULA

After balancing the results of Extraction Step 1 and Extraction Step 2 one or more curriculum specifications have been selected within one or more graduate profiles:

- BIP, Basic Instrumental I-Profile [Section 9];
- BCP, Basic Conceptual I-Profile [Section 10];
- MIP, MInor I-Profile [Section 11];
- MAP, MAjor I-Profile [Section 12].

Each graduate profile is described in terms of curriculum units [Sections 9 to 12].

Sources
The curriculum units refer to a number of important and current informatics curriculum sources:

CC91 Computing Curricula 1991: Report of the ACM/IEEE-CS Joint Curriculum Task Force [Appendix C];
IS97 IS'97: Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems (by ACM, AIS and AITP) [Appendix D];
ISCC99 ISCC'99: An Information Systems-Centric Curriculum '99. Program Guidelines for Educating the Next Generation of Information Systems Specialists, in Collaboration with Industry [Appendix E];
HCI92 Curricula for Human-Computer Interaction [1992] (by ACM-SIGCHI) [Appendix F];
ECDL The European Computer Driving Licence standard of competence (since 1997) [Appendix G].

Also the contents of the units is classified through reference to:
CCS ACM Computing Classification System [Appendix A];
UCSI Unified Classification Scheme for Informatics (UCSI) [Appendix B].

Size
Units are 'measured' in terms of credit points. 1 credit point equals one working day (= about 8 hours of study). The units within the different graduate profiles vary in size.

On the next page an example of a unit description is presented.

Example of a ICF-2000 unit description

BIP-01	**CONTEXT FOR INFORMATICS APPLICATIONS [1]**	**3-5 CP**
Targeted competencies	- the capability to basically recognise the context (business-wise, societal, individual, technical, managerial and historical) in which informatics applications are introduced and used - the attitude of being critically aware of the potentials of informatics applications	
Learning approaches	th ex	
Curriculum references		
CC91	Knowledge units AL AR DB HU PL SP1-3	
IS97	Courses 1 3 4	
ISCC99	Courses 11/1.0 21 22 41 42 43	
HCI92	Courses CS1 CS2	
>>> ***ECDL***	**Module 1**	
Classification		
CCS	B.0 C.0 D.0 E.0 H.0 I.0 J.0 K.1-2,3.0-7.0	
UCSI	1 2 3 4.1-4	

Learning approaches [Section 8]

th *Theoretical:*
The approach is to transfer information and to interact on it.
Typical forms of transfer and interaction are: lecturing, demonstrating, class discussion (student lead, teacher lead, interaction) and role playing. The typical setting is the classroom where individual students are brought together in classes.

ex *Exercising:*
The approach is to transfer information by letting students solve problems of various kinds (both abstract and concrete), generally with pencil and paper. The typical setting is the classroom where individual students are brought together in classes.

Main source reference: >>> ***ECDL*** **Module 1**

Making a concrete unit description

In this third extraction step for each ICF-2000 unit in the selected curriculum specification a concrete description is made using the references given. In the example the main reference is to the European Computer Driving Licence, Module 1 [Appendix G]. The actual units can be described in the own language and within the own cultural and educational tradition. Hoever, when composing the concrete unit description the specific coverage of themes, the specific orientation and the specific learning approach have to be taken into account.

Summary
Extraction Step 3: Producing unit descriptions

From the unit descriptions presented in ICF-2000 concrete unit descriptions are produced for the actual curriculum. Using the resources of worldwide accepted curricula these descriptions may be produced in the own language and in such a way that these fit the local cultural and educational setting. When composing the concrete unit description the specific coverage of themes, the specific orientation and the specific learning approach have to be taken into account in order to realise a curriculum fitting the intended target category.

REALISATION STEP SELECTING LEARNING MATERIALS FROM AVAILABLE SOURCES

Once the curriculum has been described according to local culture and educational setting, it can be realised in practice. Learning materials are essential in this. Many learning materials are now available in many languages. The current informatics curriculum sources referred to by IF-2000 have drawn on existing, widely available learning materials and resources, but also have led to the production of new learning materials and resources. Standard books have appeared and standard resources have been developed. For example Unit BIP-01 CONTEXT FOR INFORMATICS APPLICATIONS refers to the European Computer Driving Licence (ECDL), Module 1. Many learning materials in the many European languages have been developed for this module and are widely available.

The Internet and the World Wide Web have much to offer in terms of freeware and shareware resources. If Internet connectivity is available at institutional level a possibility to reduce problems with obtaining suitable learning materials and resources may be found in collaboration with other institutes where these are available. Other possibilities could originate from collaboration with business and industry, or from international co-operation with sister institutions. Also governmental or non-governmental agencies for the support of developing countries may be able to help in getting the required learning materials.

Selected learning materials may be translated by local producers of study materials into the own language or may be adapted to fit the local cultural and educational tradition.

Summary
Realisation: Select learning materials

Learning materials are essential in realising a curriculum. Use existing, widely available learning materials and resources that are referenced by ICF-2000 sources, to select from. Adapt these learning materials – if needed – to the local cultural and educational tradition.

1 Introduction

Rationale behind ICF-2000

IFIP/UNESCO ICF-2000 specifies a state-of-the-art informatics curriculum framework. IFIP TC3 strongly feels that only the state-of-the-art will do. This offers to institutions and countries where informatics education is still developing, the foundations from which to leapfrog to the front of developments. It is no use to fully repeat the development process with respect to informatics education that has already taken place elsewhere. This will only slow down developments and keep institutions and countries from closing the gap. Many opportunities arise from the field of informatics and its resulting technologies. This curriculum framework attempts to facilitate that fruitful use can be made of these opportunities.

Systematically building up a curriculum

ICF-2000 is offering an informatics curriculum framework, from which various curriculum implementations can be constructed in a straightforward way. These implementations depend on cultural, societal and institutional factors. Institutions and countries will be able to construct a modern curriculum from this framework in an implementation process in which specific needs, restrictions (for example with respect to resources) and possibilities are taken account of. Such a curriculum can also easily be extended with no consequence for the curriculum already in use: the ICF-2000 graduate profiles build upon each other.

Sources

ICF-2000 allows higher education publishers to produce learning materials in the cultural traditions of their country. Alternatively, popular high quality learning materials from developed countries may be used. This two-fold approach is supported by the many so-called source links in ICF-2000 to other prominent and current informatics curricula from leading professional informatics societies.
This mechanism also ensures that ICF-2000 can be easily kept up to date. Whenever these professional informatics bodies publish an updated curriculum these updates can be easily included in ICF-2000, which thus provides durable access to the state of the art in informatics education. The coverage of ICF-2000 can be judged by its mapping through specific source links on two current informatics classification systems that are both frequently updated.

Key asset

The term ‘curriculum’ will be used in this document in the meaning of ‘course of study’. The term ‘curriculum framework’ refers to a set of entities from which government authorities, industry, business and educational institutions may extract their own curriculum built from knowledge & skills units, in order to achieve a best fit implementation in their specific cultural, developmental and economical setting. We consider this a key asset of ICF-2000.

Terminology

There is a continuing discussion about the best term to be used for the broad area as addressed in the IFIP/UNESCO project. Staying away from this discussion, we adopt the term ‘informatics’ (or its abbreviation by the letter ‘I’), just for convenience. This term has its significance mainly in the European tradition. However, within the IFIP/UNESCO project it is intended to be nothing more than an ‘umbrella’ label. Hence, ‘informatics’ or ‘I’ refers to a diverse, yet related family of domains, including ‘computing’, ‘computer science’, ‘computer engineering’, ‘information systems’, ‘management information systems’, ‘computer information systems’, ‘software engineering’, ‘artificial intelligence’ or ‘AI’, ‘information technology’ or ‘IT’, ‘information and communication technology’ or ‘ICT’, and so on.

2 Context and relevant trends

PARADOX

In the last decade the field of informatics has shown an ongoing development, extension and linkage with other knowledge domains. In parallel we have witnessed a dramatic increase in demand for informatics and informatics-related university education from a broad and diverse population. Not only is the number of relatively distinct informatics educational programs growing, but there is also an increasing variety of educational programs in other disciplines that include informatics components in their core.

Thus, a paradox is arising. At the very same time that informatics education is emerging as an increasingly important part of core education for more and more students, we find a trend towards fragmentation within the informatics field itself. We also see informatics programmes appearing in other disciplines, where each discipline defines its own particular curricular needs and structures. This growing variety within informatics itself and in informatics programs in other disciplines creates a need for a common vision of the core concepts in informatics education.

COMMON VISION

The development of a common vision was the focus of an August'97 international Working Conference organised by Working Group 3.2 of IFIP which brought together participants from around the world. The conference concentrated on higher education, including university education and higher professional education. Its editorial paper summarises the varying views on the informatics field and comments on the fragmented approach to its teaching. The paper advocates a more integral, generic and coherent approach, and it presents preliminary notions in a search for a shared identity for the informatics field [1].

In a recent issue of Computerworld [4] the necessity to have a common view of the field is underlined. It is the last part of an article that discusses the so-called 'discipline problem' in relation to the exploding enrolment of students in computer science studies in the USA.

> *Academia also appears to have a problem sorting out one discipline from the next. "One of the big issues is that the disciplinary boundaries are so fuzzy," says Barbara Simons, president of the Association of Computing Machinery in New York. Academia tends to break computer-related concerns into finer and finer particles, but students may have trouble understanding which major is which. At Berkeley, for example, computer-related studies encompass computer engineering, computer science, electrical engineering, applied math and basic sciences. Some of those areas are put under the umbrella of a College of Engineering, while areas such as IT management are often put under the rubric of Letters and Science. But while colleges and universities struggle with defining what a computer science major is and isn't, industry must deal with an incoming workforce of graduates that it perceives to be inadequately prepared to face its fast-changing needs. John Keast, vice president and CIO at PG&E Corp. in San Francisco, said schools need to do a better job of making their graduates attractive to employers. He added that he didn't care about academic definitions of degree programs. "CIOs are measured by how well they deliver systems that meet business requirements," Keast says. "For me, it's a question of finding a graduate that has successfully melded computer science principles with business focus." How does Keast think universities are doing in preparing graduates for this challenge? "Not very well," he says.*
>
> *Some observers within academia agreed with Keast. Jack Callon, director of new program development within the School of Engineering at the University of California, Santa Cruz (UCSC), says what's needed is a whole new way of thinking about computer-related curricula - one that more directly reflects the broader needs of the real world. "Look, there's technology everywhere in the business world - in research, product development, manufacturing, sales and marketing, design and implementation, and in the user community, too," Callon says. "A university should be able to offer various program choices to address each of these various dimensions," he says.*
>
> *Some schools already are coming up with new programs that encompass both business and technical curricula. Take, for example, the growing number of colleges and universities that offer MBA degrees in*

> *technology. Callon, too, is starting a new class at UCSC that he calls "information systems management," which he contrasts to the business-school area of ITmanagement. "It's in the College of Engineering, but combines courses like economics, business and computer courses," Callon says. And he says internships are important, letting students learn to hold down a real job.*

Notions and trends as pointed out in the above citation and elaborated at the IFIP Working Conference mentioned before, are very important for any new informatics curriculum efforts. Even stronger, they probably are essential in the context of countries and educational institutions that are in a situation of change and development. In such situation financial constraints are often severe while the economic need for practical professionals with a general understanding of informatics is very great. Only a state-of-the-art approach will allow leapfrogging to forward to better conditions. This is the reason why the IFIP/UNESCO project builds heavily on the state-of-the-art thoughts that have been developed at the '97 IFIP Working Conference and its follow-up activities.

BENEFITS FROM RECENT CURRICULUM EFFORTS

There are several precedents of co-operative activities by multiple constituencies to formulate shared curricular goals for (parts of) the informatics field. Among the more prominent of these are:

- *Computing Curricula'91* is a report produced as a joint effort by the Association for Computing Machinery (ACM) and the Computer Society of the Institute of Electrical and Electronics Engineers (IEEE-CS). It specifies common requirements in nine subject areas and relies on three working methodologies and a dozen recurring concepts. It is to be reviewed and revised by ACM and IEEE-CS, resulting in a new version for the year 2000.
- *Curriculum IS'97* was presented in 1997 as a joint effort by ACM, the Association of Information Technology Professionals (AITP) and the Association for Information Systems (AIS). This 'information systems' curriculum refers to a detailed IS body of knowledge, includes specific depth of knowledge metrics, and models courses in terms of small learning units.
- *Curriculum ISCC'99* has been developed by a task force from industry and academia with support from NSF and has been presented in draft version at the ACM/SIGCSE'98 conference. It provides an information systems-centric curriculum (ISCC) that is enterprise-oriented, based on a 'profile of the graduate' specified by industry, and that emphasises professional skills. A comprehensive draft report is being reviewed and used to seek endorsement by ACM, AIS and IEEE-CS.
- *An education task force of the IEEE-CS/ACM Steering Committee is currently developing curriculum recommendations for 'software engineering'* for the Establishment of Software Engineering as a Profession.
- *Curricula for Human-Computer Interaction* is a 1992 report by SIGCHI, ACM's special interest group on Computer-Human Interaction.
- *'A Modular Curriculum in Computer Science'* was produced by IFIP for UNESCO in a revised edition in 1994. It offers a curriculum framework for 'computer science' specifically meant to be applied in developing countries. In a way ICF-2000 can be seen as a successor of this UNESCO/IFIP'94 curriculum. ICF-2000, however, will have a much broader scope and evidently could benefit from the other curriculum efforts mentioned.

As mentioned before ICF-2000 attempts to link to these sources. The framework thus allows developing countries to benefit from the many efforts of informatics professionals in the world to produce state-of-the-art curricula.

EXPERT SURVEY

Input from a parallel research project has been used in which (world wide) a spectrum of ideas, opinions, beliefs, viewed trends, state-of-the-art examples, exercises and models has been collected regarding the changes required in university/higher education-level informatics education and the basic conditions for change. An extensive list of questions has been used, containing thirty items, divided over five distinct parts: career biography, 'framed' views, open views, a new curriculum exercise and personal involvement. The survey has been sent to a range of USA university experts of various background and orientation and has yielded high quality responses.

3 ICF-2000 framework entities

The ICF-2000 framework consists of the following entities:

- *Categories of professionals*
  Categories of informatics (I-) professionals are identified in the perspective of current informatics and technological development. This identification is essential at the start of any I-curriculum implementation.
- *Graduate profiles*
  I-graduate profiles corresponding to these categories of I-professionals are specified to form the basis for an effective and efficient I-curriculum design, while taking account of its variety.
- *Core curriculum themes*
  A fundamental and broad set of I-curriculum themes allows efficient curriculum design by global, but essentially complete coverage of the informatics field.
- *Implementation factors and strategies*
  Implementation factors lead to strategies for full (or partial) implementation and controlled development, taking account of cultural, institutional and regional aspects.
- *Curriculum units*
  A well-chosen set of generic I-curriculum units allows one to take advantage of commonality among the diverse educational I-programs leading to the graduate profiles. This set is complemented with specialisation I-tracks. Each unit describes a coherent area of content (knowledge and skills) to be acquired.

4 Categories of professionals

PROFESSIONALS GRADUATED FROM HIGHER EDUCATION

ICF-2000 is dealing with university and higher professional education. This implies that in general lower level education programs or professional categories will not be considered. A description of a curriculum framework for secondary education can be found in the UNESCO/IFIP curriculum 'Informatics for Secondary Education, A Curriculum for Schools' [5]. The question is: What informatics knowledge is needed by professionals who have been educated in higher education and are starting their professional career. This knowledge should fit the role these professionals fulfil in economic life in an effective and efficient way.

THREE MAIN CATEGORIES

Looking at the role professionals play in the economic process three categories of professionals can be identified, acting or interacting with informatics in a broad sense:

A *I-user*
Non-I-professionals using ready made I-technology or I-applications in their work, for example non-informatics professionals using I-applications like text processors or I-technology like digital communication systems (many of the professionals in highly developed economies are I-users today);

B *I-appliers:*
Non-I-professionals applying I-knowledge and I-skills in areas different from informatics, for example non-informatics professionals in the economic field who use I-applications to model economic situations;

C *I-workers:*
I-professionals working in the field of informatics, for example the system engineer who as informatics professional develops I-applications or I-technology (note that the field of informatics is broad with diffuse boundaries with other disciplines).

It is important to note that I-appliers and I-workers generally will also be I-users, while I-workers may or may not be I-appliers too.
Within these three main categories eight subcategories are identified:

1 A1 Instrumental I-users;
2 B1 Conceptual I-appliers;
3 B2 Interfacing I-appliers;
4 B3 Researching I-appliers;
5 B4 Directing I-appliers;
6 C1 Operational I-workers;
7 C2 Engineering I-workers;
8 C3 Researching I-workers.

A1 INSTRUMENTAL I-USERS

Instrumental I-users use computer technology or software packages in their work. Examples can be found in word processing, using databases, making spreadsheets, preparing presentations, graphical drawing, communicating by e-mail, retrieving information through internet, videoconferencing, etc. As stated above, in the highly developed countries many of the workers have to be classified today as instrumental I-users, independent on their level of profession (from truck driver or bank employee to teacher or industrial executive). This proportion of workers may be expected to grow to 100 %.

B1 CONCEPTUAL I-APPLIERS

Conceptual I-appliers apply specific knowledge from the informatics domain or typical informatics skills in their own area that is increasingly infused by informatics. Examples are teachers who design computer supported education, chemists doing molecular modelling, computer artists, the media specialists applying internet technology, economists introducing electronic commerce, etc.
Today this category is only a fraction of the size of the instrumental I-users category, but because of growing interdisciplinary application of informatics the number of conceptual I-appliers is supposed to expand rapidly.

B2 INTERFACING I-APPLIERS

Interfacing I-appliers combine knowledge and skills from their own area or profession with informatics knowledge and skills, in an interfacing role linked to I-professionals. Examples are the business consultant advising in the development process of computer based information systems, the mechanical engineer participating in industrial automation projects, the sociologist supporting the introduction of large scale work computerisation, the ethicist advising on privacy matters, the lawyer collaborating on the formulation of software contracts, etc.
As with B1, category B2 is supposed to grow, although not as fast as B1.

B3 RESEARCHING I-APPLIERS

Researching I-appliers combine knowledge and skills from their own research areas with informatics knowledge and skills, in research efforts that connect and integrate informatics with other disciplines. In general such interdisciplinary research projects show fruitful collaborations with informatics researchers (see category C3) and are supposed to open up new horizons. Examples can be found in research on distance learning, human-computer interaction, cognition, computational science, telematics & multimedia, linguistics, information science, knowledge technology, logistics, etc.
The relative growth rate of category B3 might be of the same order as of category B2.

B4 DIRECTING I-APPLIERS

Directing I-appliers are well equipped and skilled by a general understanding and broad overview of informatics, to play a policymaking, supervising or managing role in the areas of I-technology and I-applications. Examples are the project manager running a project in which new I-technologies are introduced into an organisation or in which a tailored I-application is being developed, the information (policy) manager supervising the contents of information processing within an organisation, the communication (policy) manager responsible for creating, updating and exploiting an internet site of substantial volume, the (I-oriented) manager of an I-department, etc.
Again, the relative growth rate of category B4 might be similar to that of category B2 (and B3).

C1 OPERATIONAL I-WORKERS

Operational I-workers have a thorough understanding of and well-developed skills in informatics as a broad discipline, more specifically in the area of exploitation, control and maintenance of available I-technology and I-applications. Clearly this category contains a large portion of lower level I-professionals, for example computer operators, network operators, application administrators, database administrators, helpdesk employees, etc. But also university-level I-professionals will be required in directing, supervising and managing roles with respect to this area (note that there may be overlap with category B4).
We have witnessed an increase of capacity in this segment and one would expect a continuing growth.

C2 ENGINEERING I-WORKERS

Engineering I-workers have a thorough understanding of and well-developed skills in informatics as a broad discipline, more specifically in the area of analysis, design and implementation of I-systems.

Examples are the information systems analyst, the software engineer, the knowledge engineer, the scientific programmer, the database developer, the IC designer, etc.
With the expansion of I-technology and I-applications in all kinds of processes and the increasing complexity and interaction of I-systems one would expect a continuing growth of this category C2.

C3 RESEARCHING I-WORKERS

Researching I-workers have a thorough understanding of and well-developed skills in informatics as a broad discipline, more specifically in research. They are supposed to further develop the I-discipline and its concepts, both on its own and in relation with other disciplines, in the latter case collaborating with researchers from category B3.
One would expect growth for category C3, although probably less than for categories C1 and C2.

5 Graduate profiles

In order to efficiently and effectively cater for the educational needs of the identified categories of professionals it is helpful to introduce graduate profiles. ICF-2000 offers four graduate I-profiles.

BIP BASIC INSTRUMENTAL I-PROFILE

This profile is necessary for and satisfies the educational demands of category A1, the instrumental I-user. The profile is also required, but of course not sufficient, for all other categories. It is natural to think of curriculum units that are generic for all disciplines X (including I), but also of units that are specifically linked to particular disciplines X (again including I).

BCP BASIC CONCEPTUAL I-PROFILE

This profile is required for category B1, the conceptual I-applier. Again we may expect generic curriculum units for all disciplines and specific units for the various disciplines X.

MIP MINOR I-PROFILE

The minor profile is meant for the remaining categories of I-appliers: B2, B3 and B4 (note that this profile extends beyond the basic conceptual profile, which is considered to be a subset of the minor profile). We may recognise a 'common core' of curriculum units, that is generic for all disciplines as well as for the three categories of I-appliers (B2, B3 and B4). In addition there will be specific curriculum units that may vary with respect to both these three categories and the particular disciplines X.

MAP MAJOR I-PROFILE

The major profile is relevant to the three categories of I-workers: C1, C2 and C3 (note - like before - that the major profile extends and includes the minor profile, MIP). Among these a common core of generic curriculum units will be apparent as well as curriculum units that are specific for the three categories, including certain specialisations within the I-discipline or in interdisciplinary areas shared with other disciplines X.

NON-INFORMATICS SUBJECTS

Clearly, the graduate I-profiles do not all constitute a full curriculum. BIP will only be a small supporting part of large educational programs in whatever area. In that case it is the area of interest that actually determines the profile of the program. In other words, you will be educated to become, for example, a chemist, but you do need some basic instrumental informatics skills and knowledge. The relative contribution of the graduate I-profile to the complete program is increasing in the order BIP – BCP – MIP – MAP, the latter being the dominant and profiling part indeed of a curriculum that educates I-professionals (or informaticians).

Non-informatics subjects that (may) contribute to the breadth of a full curriculum or support the graduate I-profiles will not receive specific attention in the IFIP/UNESCO ICF-2000 project, since these fall outside its scope. Potential subjects arise from disciplines like:

- mathematics;
- science;
- engineering;
- economics;
- management sciences;
- law;
- psychology;

- linguistics;
- philosophy;
- social sciences (in general).

6 Core curriculum themes

TWELVE THEMES

In ICF-2000 a fundamental and broadly based set of I-curriculum themes is used that globally offers a complete coverage of the informatics field. These core curriculum themes contribute to the generic parts of the four graduate I-profiles. The themes essentially set the curriculum framework and define the core of informatics education. These also allow clarifying the relationship of informatics with other disciplines.

The chosen set of themes has been produced and critically discussed at an August'97 IFIP/Working Group 3.2 Conference. This working conference had high quality participation from around the world, representing recent thoughts, opinions, beliefs and viewed trends. At the conference three focus groups were active, of which two reported independently on respectively a Major and a Minor common core for informatics. These appeared to be almost identical (apart from the competence levels to be achieved). The reports are included in [1]. Below the integrated set of twelve core curriculum themes (in terms of subjects, issues, concepts and skills) is presented. This set is to be used as a guidance and reference for the various curriculum units required in the four generic graduate I-profiles.

1 REPRESENTATION OF INFORMATION

Perhaps the most fundamental concern of the field is information. And whatever the domain of discourse, to enable manipulation and communication requires that the information be represented symbolically.
Examples are: symbols, various natural languages, sound and colour, bits and bytes, encryption and compression.

2 FORMALISM IN INFORMATION PROCESSING

Information processing requires underlying formalism, i.e. the manipulation of forms that represent information about a domain. Although information in the real world may take many physical forms, it must be coded as discrete values in order to allow formal processing by a program.
Examples of supporting areas: discrete mathematics, logic, and artificial languages. Note however the required awareness that computing systems are vast compared with previous modes of mathematical modelling.

3 INFORMATION MODELLING

Manipulating information (or its representation) is important precisely because we obtain understanding of situations or phenomena. Whenever you write a program or design a system to solve a problem, you are modelling the world (or a specific domain). Critical to the discussion of information modelling is an appreciation of the complexity of the phenomena to be modelled. This will reveal certain inadequacies and difficulties in the very paradigm of informatics.
Relevant topics are: abstract data types, object orientation, information systems, and databases. But also: data collection, ambiguity, effects of policy and social parameters, information loss, etc.

4 ALGORITHMICS

It is a truism that computing is accomplished by algorithms and data structures. So awareness of key concepts in the design and analysis of algorithms is core to any informatics educational program.
Relevant topics are: complexity (time and space), comparing algorithms, selection and design of algorithms, data structures.

5 SYSTEM DESIGN

The various fields of informatics have always been involved with the construction of systems. Perhaps due to increasing awareness of engineering methodologies, more recent attention has been given to elements of good design (e.g. the emergence of the discipline of software engineering).
Relevant topics are: requirements analysis, specification, design, implementation, testing and validation, maintenance, documentation, human-computer interaction, security, quality, prototyping, rapid application development, method engineering.

6 SOFTWARE DEVELOPMENT

Hands-on experiences in the methods of programming are taken to be core experiences, though they may be interpreted quite broadly and not strictly limited to standard programming languages.
Relevant topics are: programming methods, programming paradigms, programming environments, case tools, database systems, spreadsheets, modularity, reusability, generation and assembly of programs, design patterns.

7 POTENTIALS AND LIMITATIONS OF COMPUTING AND RELATED TECHNOLOGIES

It goes without saying that all informatics practitioners need a keen appreciation of the capabilities of the computing paradigm. They will be adding to those capabilities during the course of a career. In addition the 'whole person' practitioner should be at least aware of limitations of the paradigm, from both theoretical and pragmatic points of view.
Examples are: breadth and scope of feasible applications, complexity, correctness, (non-)computability (e.g. the halting problem), unfeasibility (e.g. the travelling salesman problem). Note that there is no need to know the last two examples very deeply, they can be presented in a simple, plausible and motivating way.

8 COMPUTER SYSTEMS AND ARCHITECTURES

Core knowledge includes awareness and demonstrated abilities concerning the diverse parts of a computer system through a functional model.
Relevant topics are: hardware components, systems software, operating systems, embedded systems, tools, comparison and evaluation.

9 COMPUTER-BASED COMMUNICATION

Since computer-based communication has become a pervasive way of interaction, it is of key concern to understand the conceptual workings of such systems, in particular in various types of networks and the concepts of Human-Computer Interaction (HCI).
Relevant topics are: data communication, local and wide area networks, world wide web, internet, intranet, coding and decoding, need for standards, security, computer graphics, human-computer interfaces, multimedia.

10 SOCIAL AND ETHICAL IMPLICATIONS

While often acknowledged as important for the informatics professional, there never seems to be sufficient time in a curriculum to tackle concepts in these areas. Possibly through seminars, case studies, role-playing, field trips and guest speakers, formal attention must be given to this area.
Relevant topics are: privacy, intellectual property, professional issues, equity in access, codes of ethics, social change.

11 PERSONAL AND INTERPERSONAL SKILLS

It has been stated that the era of the solo asocial programmer has come to an end. Through a maturing of the field, as well as the awesome complexity of the problems to be solved, effective teamwork has become crucial in the construction of the resulting extremely complex systems.

Examples of skills required are: communication, team work, critical thinking, leadership, working with users, interdisciplinary environments, written specifications and documentation, dealing with ambiguity.

12 BROADER PERSPECTIVES AND CONTEXT (INCLUDES LINKS WITH OTHER DISCIPLINES)

Some knowledge and understanding may not be directly relevant to the design of an information system yet is still considered as core to informatics. This would be similar to an acknowledgement that a solid grounding in the liberal arts is core to any educated person. One should be aware that informatics has a very rich and lengthy history (far predating electronics and involving some of the giants of the world's intellectual heritage) and exceedingly deep philosophical implications. Examples of areas to be linked to are: history, philosophy, artificial intelligence, cognitive science, linguistics, scientific modelling.

7 Implementation factors and strategies

A SERIES OF IMPLEMENTATION FACTORS

ICF-2000 does not aim at offering one ideal model curriculum. Instead it recognises that a considerable degree of freedom for implementation is needed to be able to account for specific needs, restrictions, preconditions and circumstantial opportunities. Numerous regional and institutional factors influence implementation:

a cultural and societal setting;
b institutional size and scope;
c specific disciplines and educational programs offered by the educational institution;
d available budget, personnel and resources;
e available infrastructure;
f background and potential of the faculty;
g culture among faculty and management;
h management commitment to informatics;
i willingness to change;
j student body characteristics;
k access to informatics learning materials;
l access to informatics expertise in general;
m access to collaborative or transfer options with other institutes;
n access to collaborative or transfer options with industry;
o level of informatics penetration in the region.

In order to be able to judge correctly what level of implementation is needed and possible in a particular case, it is crucial to assess these implementation factors as far as feasible, to make a mutual comparison (they are certainly not all equally significant!) and - on the basis of this analysis - to decide for a particular strategic option. Since this is not at all a straightforward procedure, let us consider two example cases to get a better feel for how this is done.

IMPLEMENTATION CASE I

Consider:

- a small educational institution (b), offering only a few major programs (b, c),
- with a relatively low budget (d) and a rather primitive infrastructure (e),
- with no informaticians as teaching staff (f),
- but with enthusiasm for a general use of informatics and specific software packages (g, h),
- and a strong commitment to introduce such new elements in the curricula (h, i),
- but lacking good access to informatics expertise in the region (l, m, n).

An appropriate strategic option would be to implement only a Basic Instrumental I-Profile (BIP) [Section 5], satisfying the educational demands of the largest category of professionals, that of the instrumental informatics users (A1) [Section 4].

However, if this same educational institution has:

- at least one staff member who has pioneered in informatics teaching (f),
- and who is willing to help realise some informatics curriculum units (i),
- plus a regional company aiming at collaboration (n),
- and offering some financial support to improve the infrastructure (e),

one could be more ambitious and decide to implement additionally a Basic Conceptual I-Profile (BCP, see section 5), by which the conceptual informatics appliers (B1) [Section 4] among different major programs could be educated.

IMPLEMENTATION CASE II

Consider:
- a large educational institution (b), offering a whole range of major programs (b, c),
- with a specific budget allocated to further informatics efforts (d) and to investments for improving the infrastructure (e),
- with a teaching staff including one or more qualified informaticians (f),
- offering already the Basic Instrumental and Conceptual I-Profiles (BIP and BCP, see section 5) through most of the major programs (b, c),
- strongly determined to explore informatics as a discipline (g, i),
- a strong interest among students to take an informatics minor (j),
- and good access to informatics expertise in industry and in other institutions (l, m, n),
- as well as upcoming small informatics companies in the region (o).

An appropriate strategic option would be to supplement the already existing profiles BIP and BCP with both the MInor and the MAjor I-Profiles (MIP and MAP) [Section 5]. The institution could then offer possibilities to be educated in the informatics appliers categories [Section 4] (conceptual, interfacing, researching, directing), as well as in the informatics workers categories [Section 4] (operational, engineering, researching). But of course one could also decide to aim for only a selection of these categories (e.g. to drop both researching categories).

However, if this same educational institution has:
- a strong resistance among non-I faculty against a new informatics major at the institution (g),
- and a management that is not convinced of the future of stand-alone informatics programs (h),

it might be wise to be less ambitious and not to introduce the MAjor I-Profile (yet).

FACULTY, INFRASTRUCTURE AND LEARNING MATERIALS

At this place we would like to give special attention to three of the implementation factors mentioned above:
- background and potential of the faculty;
- available infrastructure;
- access to informatics learning materials.

Faculty

Informatics is a new discipline. It will therefore in general be difficult to find enough qualified faculty to run informatics educational programs in higher education. One possibility to reduce these faculty problems may be found in collaborative or transfer options with other institutes where such informatics expertise is available. Another possibility may be found in collaboration with business and industry. If the level of informatics penetration in the region is low, national or international co-operation with sister institutions might help to reduce faculty problems. In most cases a faculty staff development program will be necessary.

Staff development can be undertaken while curriculum implementation is under way. It is not advisable to go for an immediate full-scale implementation of the most advanced educational program. Rather the educational program should be developed in stages, starting with BIP, and then adding BCP. After that MIP can be developed, and if appropriate MAP. Staff development can be part of the development in these stages.

Infrastructure

Informatics is a practical discipline and informatics education therefore has a substantial practical component. This poses infrastructural problems: hardware and software of the right quality and in the right quantity have to be available for educational purposes. The hardware and software facilities need organisational and maintenance support of non-trivial nature. In most cases a support centre

with capable staff will have to be established. In other cases support may be arranged through local businesses.

Even when the infrastructure is not very advanced much can be done. Implementation of the Basic Instrumental Profile (BIP) can be undertaken step-by-step, thereby gradually providing more required instrumental skills.

Learning materials
In the last decade informatics has matured as a discipline. As a result many learning materials are now available in many languages. In the Acknowledgement section and in section 2 of this document we refer to a number of prominent curriculum efforts. These efforts have drawn on existing, widely available learning materials and resources, but they also have led to the production of new learning materials and resources. Standard books have appeared and standard resources have been developed.

The Internet and the World Wide Web have much to offer in terms of freeware and shareware resources. If Internet connectivity is available at institutional level a possibility to reduce problems with obtaining suitable learning materials and resources may be found in collaboration with other institutes where these are available. Other possibilities again could originate from collaboration with business and industry, or from an international co-operation with sister institutions. Also governmental or non-governmental agencies for the support of developing countries may be able to help in getting the required learning materials.

GLOBAL IMPLEMENTATION OVERVIEW

Below we present an implementation chart that shows opportunities and options at three stages of development:

- initial;
- intermediate;
- advanced.

The outcome of the balanced score of the complex of all the implementation factors (a)-(o), on the first line of the implementation chart, actually positions the educational institution at a certain stage. We will not address here the matter of how to weigh the individual implementation factors and just give a few examples of possible values in the implementation chart, under the broken line. By this we want to indicate that of course there is a relation between these implementation factors and the final overall judgement for a ‘0’, a ‘+’, or a ‘++’, but not necessarily through the same column of the implementation chart. For example, a large institution (put in the ‘advanced stage’ column) may very well be not equipped appropriately for the advanced stage, as we have explained under case II.

Furthermore we would like to underline the position we have taken in the implementation chart, namely that the Basic Instrumental I-Profile BIP on itself, although extremely important, is not considered as a distinguishing profile for the manifestation of informatics in the various educational programs. Therefore the initial stage is constrained to also include the Basic Conceptual I-Profile BCP at the minimum.

Characteristics	***Initial stage***	***Intermediate stage***	***Advanced stage***
Balanced score on the complex of implementation factors (a)-(o)	0	+	++
e.g.:			
(b) institutional size and scope	small	medium	large
(e) available infrastructure	not very advanced hard/software	more hard/software of good quality + support centre	more and specialised hard/software + support centre
(f) background and potential of the faculty	several faculty with a Minor in informatics	+ at least some faculty with a Major in informatics	+ several faculty with a Major in informatics (in an I-department) + several faculty with a Minor in informatics in other departments
Graduate I-profiles	Basic Instrumental I-Profile (BIP) Basic Conceptual I-Profile (BCP)	*initial, plus*: MInor I-Profile (MIP)	*intermediate, plus*: MAjor I-Profile (MAP)
Graduates	Majors in other disciplines X (+ spec.tracks in I)	*initial, plus:* Minors in I	*intermediate, plus:* Majors in I
Categories of educated ***professionals*** [Section 4]	Instrumental I-users (A1) Conceptual I-appliers (B1)	*initial, plus:* Interfacing I-appliers (B2) *and/or* Researching I-appliers (B3) *and/or* Directing I-appliers (B4)	*intermediate, plus:* Operational I-workers (C1) *and/or* Engineering I-workers (C2) *and/or* Researching I-workers (C3)

8 Curriculum description

CURRICULUM SPECIFICATIONS

ICF-2000 identifies 4 different graduate profiles:

- BIP, Basic Instrumental I-Profile [Section 9];
- BCP, Basic Conceptual I-Profile [Section 10];
- MIP, MInor I-Profile [Section 11];
- MAP, MAjor I-Profile [Section 12].

However, professional categories have characteristics that lead to differences within the graduate profiles. These differences are related to:

- The coverage of informatics themes [Section 6];
- The orientation in terms of goals and competencies to be reached.

A *curriculum specification* is a graduate profile that is tailored to meet the educational informatics needs of a specific professional category.

Themes

Themes [Section 6] are coded by numbers:

1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;
8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

The coverage of the themes is a 'fingerprint' of the curriculum specification fitting a specific category of professionals.

Orientations

Each unit will have a dominant orientation (in terms of goals, competencies), one out of four types (in two-letter codes):

AW *AWareness (know or use):*
Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages;

AP *APplication:*
Aiming at developing a basic conceptual understanding of informatics and of some more advanced informatics skills which allow students to apply basic informatics to other disciplines or areas;

DM *Design and Modelling:*
Aiming at developing a general understanding and broad overview of informatics, especially with respect to the modelling and the design of informatics applications;

CA *Conceptualisation and Abstraction:*
Aiming at developing a thorough understanding of and well-developed skills in informatics as a broad discipline, the essence being to further develop the capability of students to abstract and to conceptualise.

Credit points
The size of the graduate profiles is measured in credit points. 1 credit point equals one working day (= about 8 hours of study). Also the size of units is measured in terms of credit points. The units within the different graduate profiles vary in size.

Example of a curriculum specification for professional category A1

Curriculum specification of BIP

Graduate I-profile	**BIP**	**BASIC INSTRUMENTAL I-PROFILE**															
Categories of professionals	A1	Instrumental I-users															
		credit points (total)		credit points (generic)			credit points (discipline specific)										
Size of educational program	***BIP***	***20***		***16***			***4***										
Prerequisites	none																
Constituting units			*size*	*orien-*	---------- *themes* ----------												
code	*title*		*[cp]*	*tation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	
[--- generic ---]																	
BIP-01	Context for informatics applications [1]		3-5	AW	x		x		x		x	x	x	x		x	
BIP-02	Hands-on with software packages [1]		3-5	AW	x		x	x			x	x			x		
BIP-03	Hands-on with software packages [2]		3-5	AW	x		x	x			x	x			x		
BIP-04	Hands-on with networking [1]		3-5	AW	x						x		x		x		
[--- discipline(X) specific --- X may be I ---]																	
BIP/X-01	Operating software in area X [1]		4	AW							x				x	x	
	Total size & theme 'fingerprint'		**20**	**AW**	**4**		**3**	**2**	**1**		**5**	**3**	**2**	**1**	**4**	**2**	

1 credit point (cp) = 1 day of study

Orientation:
AW *AWareness (know or use):*
Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages.

Themes
1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;
8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

UNITS

Curriculum units of ICF-2000 are building blocks of variable size, which we will refer to as units.

Format of a unit specification

Each unit in ICF-2000 is described or specified by the following attributes:

- a unit *code*, referring to one of the four graduate profiles: {BIP-#, BCP-#, MIP-#, MAP-#};
- an explanatory *title*: {short name, comprehensive sentence};
- *targeted competencies* in terms of capabilities and attitudes;
- preferred mix of *learning approaches:* {th = theoretical, pr = practical, ex = exercising, rl = real-life} [see below];
- specific *references* to important and current informatics curriculum *sources*: {CC91, IS97, ISCC99, HCI92, ECDL} [see below]; one source is identified as main source of reference;
- *classification* according to important and current taxonomies {CCS, UCSI}.

Source references

ICF-2000 refers to a number of important and current informatics curriculum sources. These are:

CCS	The ACM Computing Classification System [1998 Version];
UCSI	The Unified Classification Scheme for Informatics [release 1.2, 1997];
CC91	Computing Curricula 1991: Report of the ACM/IEEE-CS Joint Curriculum Task Force;
IS97	IS'97: Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems (by ACM, AIS and AITP);
ISCC99	ISCC'99: An Information Systems-Centric Curriculum '99. Program Guidelines for Educating the Next Generation of Information Systems Specialists, in Collaboration with Industry;
HCI92	Curricula for Human-Computer Interaction [1992] (by ACM-SIGCHI);
ECDL	The European Computer Driving Licence standard of competence [since 1997].

The first two sources are knowledge domain classification systems for 'computing' and 'informatics' respectively, the other five sources are model curricula descriptions (although IS97 also includes an IS body of knowledge classification). These references are useful since they generally are very comprehensive and offer a lot of relevant information. Each of the seven sources has its own appendix in this working document (A through G), containing only a fraction of the available information and edited in view of its use for ICF-2000.

Learning approaches

The following learning or didactic approaches (associated with two-letter codes) are distinguished:

th *Theoretical:*
The approach is to transfer information and to interact on it.
Typical forms of transfer and interaction are: lecturing, demonstrating, class discussion (student-lead, teacher-lead, interaction) and role-playing. The typical setting is the classroom where individual students are brought together in classes.

pr *Practical:*
The approach is to have the students perform practical activities (for which information is necessary). Typical practical activities are: laboratory work, presentations by students, gaming/simulation and case project activities. A typical setting is a computer laboratory where students work individually and in small teams.

ex *Exercising:*
The approach is to transfer information by letting students solve problems of various kinds (both abstract and concrete), generally with pencil and paper. The typical setting is the classroom where individual students are brought together in classes.

rl *Real-life:*
The approach is to have students solve real-life or nearly real-life problems.
Typical student activities are: team based assignment and team based project work. The typical setting is a classroom or computer laboratory where students work, either as individual expert or in large teams.

Example of a unit specification

BIP-01	**CONTEXT FOR INFORMATICS APPLICATIONS [1]**	**3-5 CP**
Targeted competencies	- the capability to basically recognise the context (business-wise, societal, individual, technical, managerial and historical) in which informatics applications are introduced and used - the attitude of being critically aware of the potentials of informatics applications	
Learning approaches	th ex	
Curriculum references		
CC91	Knowledge units AL AR DB HU PL SP1-3	
IS97	Courses 1 3 4	
ISCC99	Courses 11/1.0 21 22 41 42 43	
HCI92	Courses CS1 CS2	
>>> ***ECDL***	**Module 1**	
Classification		
CCS	B.0 C.0 D.0 E.0 H.0 I.0 J.0 K.1-2,3.0-7.0	
UCSI	1 2 3 4.1-4	

Main source reference: >>> ***ECDL*** **Module 1**

SCOPE OF THE CURRICULUM DESCRIPTION

It is important to be clear about what ICF-2000 actually covers: what is the level of detail in the curriculum units in terms of units, what matters are not addressed or elaborated, what choices or assumptions have been made, etc. Therefore please note that ICF-2000:

- does not address the question of what *non-informatics* subjects should be included in order to *support* the various graduate I-profiles (from disciplines like: mathematics, science, engineering, economics, management sciences, law, psychology, linguistics, philosophy, social sciences in general);
- presents a *first order exercise* on the specification of graduate profile units that will be further reviewed, evaluated, updated, expanded and refined;
- heavily builds on the *source references* mentioned before, thereby giving access to a relevant and vast body of information, including suggested learning;
- initially *estimates the size* of the generic graduate profiles to be: 16, 32, 64 and 128 credit points for BIP, BCP, MIP and MAP respectively; for each graduate profile the total specific unit is estimated to be 25% of the profile's generic component (as a maximum);

9 Basic Instrumental I-Profile (BIP)

Professional category: A1 Instrumental I-users

CURRICULUM SPECIFICATION OF BIP

Graduate I-profile	**BIP**	**BASIC INSTRUMENTAL I-PROFILE**	
Categories of professionals	A1	Instrumental I-users	
		credit points (total)	credit points (generic)	credit points (discipline specific)
Size of educational program	***BIP***	***20***	***16***	***4***
Prerequisites	none			

Constituting units		*size*	*orien-*	*themes*											
code	*title*	*[cp]*	*tation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
[--- generic ---]															
BIP-01	Context for informatics applications [1]	3-5	AW	x		x		x		x	x	x	x		x
BIP-02	Hands-on with software packages [1]	3-5	AW	x		x	x			x	x			x	
BIP-03	Hands-on with software packages [2]	3-5	AW	x		x	x			x	x			x	
BIP-04	Hands-on with networking [1]	3-5	AW	x						x		x		x	
[--- discipline(X) specific --- X may be I ---]															
BIP/X-01	Operating software in area X [1]	4	AW							x				x	x
	Total size & theme 'fingerprint'	**20**	**AW**	**4**		**3**	**2**	**1**		**5**	**3**	**2**	**1**	**4**	**2**

1 credit point (cp) = 1 day of study

Orientation:

AW *AWareness (know or use):*
Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages.

Themes

1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;
8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

UNIT SPECIFICATIONS FOR BIP [GENERIC]

BIP-01	**CONTEXT FOR INFORMATICS APPLICATIONS [1]**	**3-5 CP**

Targeted competencies
- the capability to basically recognise the context (business-wise, societal, individual, technical, managerial and historical) in which informatics applications are introduced and used
- the attitude of being critically aware of the potentials of informatics applications

Learning approaches th ex

Curriculum references

CC91	Knowledge units	AL	AR	DB	HU	PL	SP1-3	
IS97	Courses	1	3	4				
ISCC99	Courses	11/1.0	21	22	41	42	43	
HCI92	Courses	CS1	CS2					
>>> ***ECDL***	**Module**	**1**						

Classification

CCS	B.0	C.0	D.0	E.0	H.0	I.0	J.0	K.1-2,3.0-7.0
UCSI	1	2	3	4.1-4				

BIP-02	**HANDS-ON WITH SOFTWARE PACKAGES [1]**	**3-5 CP**

Targeted competencies
- the skills to act basically literate with respect to computers, an operating system and a selection of standard software packages for processing of e.g. text and documents, spreadsheets, databases, presentations, graphics
- the attitude of having no fear for operating a computer and using its most common standard software

Learning approaches pr ex

Curriculum references

CC91	Knowledge units	DB	OS			
IS97	Courses	P0A,D-F	1J	4C,F		
ISCC99	Courses	11/4.0	41			
>>> ***ECDL***	**Modules**	**2**	**3**	**4**	**5**	**6**

Classification

CCS	D.4.0	H.2.0,5.0	I.3.0,7.0	K.8.0-1
UCSI	1.5	3.13.4	4.2.2	

BIP-03	**HANDS-ON WITH SOFTWARE PACKAGES [2]**	**3-5 CP**

Targeted competencies
- the skills to perform more advanced operations in an operating system and a selection of standard software packages for processing of e.g. text and documents, spreadsheets, databases, presentations, graphics, …
- the attitude of being self-confident with respect to discovering various functionalities of common standard software

Learning approaches pr ex

Curriculum references

	CC91	Knowledge units DB OS
	IS97	Courses P0A,D-F 1J 4C,F
	ISCC99	Courses 11/4.0 41
>>>	***ECDL***	**Modules 2 3 4 5 6**

Classification

CCS	D.4.0 H.2.0,5.0 I.3.0,7.0 K.8.0-1
UCSI	1.5 3.1 3.4 4.2.2

BIP-04	**HANDS-ON WITH NETWORKING [1]**	**3-5 CP**

Targeted competencies
- the skills to act basically literate with respect to electronic communication networks and a selection of functionalities such as electronic mail, information retrieval, file transfer, teleworking, collaborative work, …
- the attitude of feeling free to explore the full potential of electronic communication networks

Learning approaches pr ex

Curriculum references

	CC91	Knowledge units OS9 SP1
	IS97	Courses P0B-C,G 1K 2D 6 7F
	ISCC99	Courses 21/2.0 42
>>>	***ECDL***	**Module 7**

Classification

CCS	C.2.0 H.3.0 K.8.0-1
UCSI	1.4 3.4 4.2.2

UNIT SPECIFICATIONS FOR BIP [DISCIPLINE(X) SPECIFIC – X MAY BE I]

BIP/X-01 **OPERATING SOFTWARE IN AREA X [1]** **4 CP**

Targeted competencies
- the skills to effectively work with a software package to be applied in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …, or informatics itself)
- the attitude of aiming at a useful starter's degree of mastering such a software package

Learning approaches th pr ex

Classification

CCS	J.1-7	K.8.0-1
UCSI	4.2	

Notes

a The informatics model curricula do not offer useful references for this unit.

b It is important that a sister department be involved in joint efforts.

c Examples of applications are (in alphabetical order): authoring/educational systems, computer algebra, data mining and marketing, desktop publishing, document management, electronic commerce, electronic democracy, enterprise resource planning (ERP), financial planning, HRM systems, medical systems, multimedia software, scientific computing, simulation, statistical processing, virtual reality, workflow management, …

10 Basic Conceptual I-Profile (BCP)

Professional category: B1 Conceptual I-appliers

CURRICULUM SPECIFICATION OF BCP

Graduate I-profile	**BCP**	**BASIC CONCEPTUAL I-PROFILE**		
Categories of professionals	B1	Conceptual I-appliers		
		credit points (total)	credit points (generic)	credit points (discipline specific)
Size of educational program	***BCP***	***40***	***32***	***8***
Prerequisites	BIP	20	16	4
	Total	**60**	**48**	**12**

Constituting units		*size*	*orien-*	*themes*											
code	*title*	*[cp]*	*tation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
[--- generic ---]															
BCP-01	Context for informatics applications [2]	3-5	AP							x			x		x
BCP-02	Architecture of information systems [1]	3-5	AP	x	x	x		x							
BCP-03	Architecture of software systems [1]	3-5	AP		x		x		x						
BCP-04	Architecture of computer systems [1]	2-4	AP							x	x				
BCP-05	Networking and communication [1]	2-4	AP							x		x	x		
BCP-06	Hands-on with networking [2]	2-4	AP							x		x		x	
BCP-07	Formalism in information processing [1]	2-4	AW	x	x	x	x			x					
BCP-08	Modelling and system development [1]	4-6	AW			x		x						x	
BCP-09	Miscellaneous / state-of-the-art [1]	3-5	AW							x					x
[--- discipline(X) specific --- X may be I ---]															
BCP/X-01	Informatics concepts in area X [1]	2-4	AP	x	x	x	x	x	x				x	x	
BCP/X-02	Informatics applications in area X [1]	2-4	AP						x			x		x	
BCP/X-03	Operating software in area X [2]	2-4	AP						x				x	x	
	Total size & theme 'fingerprint'	**40**	**AP [AW]**	**3**	**4**	**4**	**3**	**3**	**2**	**8**	**1**	**2**	**3**	**4**	**5**

1 credit point [cp] = 1 day of study

Orientation:

AW *AWareness (know or use):*
Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages;

AP *APplication:*
Aiming at developing a basic conceptual understanding of informatics and of some more advanced informatics skills which allow students to apply basic informatics to other disciplines or areas.

Themes

1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;

8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

UNIT SPECIFICATIONS FOR BCP [GENERIC]

BCP-01	**CONTEXT FOR INFORMATICS APPLICATIONS [2]**	**3-5 CP**

Targeted competencies
- the capability to understand and describe the context (business-wise, societal, individual, technical, managerial and historical) in which informatics applications are introduced and used
- the attitude of aiming at the inclusion of contextual aspects associated with informatics applications

Learning approaches th ex

Curriculum references

	CC91	Knowledge units SP1-3 SU25
>>>	***IS97***	**Courses 1C-D,F-G,L 2A-G 3A,C,E-H,K,M**
	ISCC99	Courses 11 22 44

Classification

	CCS	J.0 K.1-2,3.0-7.0
	UCSI	4.1-4

BCP-02	**ARCHITECTURE OF INFORMATION SYSTEMS [1]**	**3-5 CP**

Targeted competencies
- the capability to basically understand and handle the architectural aspects of databases, information systems and knowledge-based systems (models, concepts, languages, constructs, representations, environments, …)
- the attitude of appreciation of the elegance and effectiveness of an architectural approach to information systems

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units DB SU11
>>>	***IS97***	**Courses 1A-B,E,J 2J 3A,C-D 8A-C**
	ISCC99	Courses 11 21/1.041/1.0-3.0

Classification

	CCS	H.1.0-4.0
	UCSI	3.1 3.2

BCP-03 **ARCHITECTURE OF SOFTWARE SYSTEMS [1]** **3-5 CP**

Targeted competencies - the capability to basically understand and handle the architectural aspects

of computer programs and software systems (algorithms, data structures, languages, constructs, modules, components, paradigms, processors, environments, …)
- the attitude of appreciation of the elegance and effectiveness of an architectural approach to software systems

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units**	**AL**	**PL**
	IS97	Courses 1H-I	5	
	ISCC99	Course 31/1.0-2.0		

Classification

	CCS	D.1.0,3.0	E.1
	UCSI	2.1 2.2	

BCP-04 **ARCHITECTURE OF COMPUTER SYSTEMS [1]** **2-4 CP**

Targeted competencies - the capability to basically understand and handle the architectural aspects

of hardware, digital systems, computer systems and operating systems (logic structure, memory structure, digital components, integrated circuits,

processors, languages, interfacing, storage, files, devices, processes, …)
- the attitude of appreciation of the elegance and effectiveness of an architectural approach to computer systems

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units**	**AR**	**OS**
	IS97	Course 4A-F		
	ISCC99	Course 21/4.0		

Classification

	CCS	B.0	C.1.0,5.0	D.4.0
	UCSI	1.1-3	1.5	

BCP-05	**NETWORKING AND COMMUNICATION [1]**	**2-4 CP**

Targeted competencies
- the capability to understand and describe the major components and characteristics of the technical infrastructure (data communication, network architectures, topologies, protocols, LAN, WAN, network management, client/server, Internet, intranet, extranet, …)
- the attitude of appreciation of the relevance of networking and electronic communication

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units AR6 OS9 SU7
>>>	***IS97***	**Courses 1K 3J-K 4G 6**
	ISCC99	Courses 21/2.042

Classification

	CCS	B.4.0 C.2.0
	UCSI	1.4

BCP-06	**HANDS ON WITH NETWORKING [2]**	**2-4 CP**

Targeted competencies
- the skills to perform more advanced operations with respect to electronic communication networks and a selection of functionalities such as electronic mail, information retrieval, file transfer, teleworking, collaborative work, …
- the attitude of being self-confident with respect to discovering various functionalities of electronic communication networks

Learning approaches pr ex

Curriculum references

	CC91	Knowledge unit OS9
	IS97	Courses P0B-C,G 1K 2D 6 7F
	ISCC99	Courses 21/2.0 42
>>>	***ECDL***	**Module 7**

Classification

	CCS	C.2.0 H.3.0 K.8.0-1
	UCSI	1.4 3.4 4.2.2

BCP-07 **FORMALISM IN INFORMATION PROCESSING [1]** **2-4 CP**

Targeted competencies - the capability to basically recognise some formal aspects with respect to information processing (a small and popularly treated selection of subjects like - in alphabetical order: abstraction, automata, coding theory,
complexity, computability, correctness, formal languages, grammars, information theory, logic, modelling, reasoning, semantics, systems theory, verification, …)
- the attitude of being aware of the power of formalisms in information processing and of the situationally dependent need to rely on formal approaches

Learning approaches th ex

Curriculum references

>>>	***CC91***	**Knowledge units AL4-5,7 PL7-10**
	IS97	Courses 1A-B 3D 5G
	ISCC99	Course 31/1.0

Classification

	CCS	E.4 F.0 H.1.0
	UCSI	2.5 3.5

BCP-08 **MODELLING AND SYSTEM DEVELOPMENT [1]** **4-6 CP**

Targeted competencies - the capability to basically understand the life cycle and the process of prototyping for the development of information systems as well as to reproduce certain parts of the process of system design (where the system may be a database, an information system or a knowledge-based system)
- the attitude of being aware of the various steps in the development process of information systems and of the need for a systematic design approach

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge unit DB
	IS97	Courses 1E 2J 7A,F-G,I-J 8A-D 10A
>>>	***ISCC99***	**Courses 11 21/1.041/1.0,3.0 61**
	HCI92	Course MIS1.2-3

Classification

	CCS	H.0
	UCSI	3.1-3

BCP-09	**MISCELLANEOUS / STATE-OF-THE-ART [1]**	**3-5 CP**

Targeted competencies

- the capability to basically understand and describe the areas of artificial intelligence, electronic commerce, human-computer interaction, multimedia and security, and a selection of the following subjects (in alphabetical order): computer graphics, computer linguistics, computer vision, datamining, data warehousing, distributed systems, embedded systems, expert systems, image processing, intellectual property, knowledge management, legal aspects, neural networks, parallel computing, pattern recognition, privacy, real-time systems, robotics, sound and music computing, virtual reality, …
- the attitude of being aware of the dynamics in the informatics field and of being curious about new developments

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units AL9 AR7 AI HU OS10 PL12 SP3-4 SU**
>>>	***IS97***	**Courses 2B-C,I 3I,K 8E-G 9A**
>>>	***ISCC99***	**Courses 21/3.022/1.3-4 32/3.0-4.0 43 51 EL/T**
>>>	***HCI92***	**Courses CS1 CS2 PSY1**

Classification

CCS	B.0,C.0,D.0,E.0,H.0 H.1.2,5.0 I.2.0-5.0 K.4.4,5.0,6.5
UCSI	1-4 2.43.43.5.2-3

UNIT SPECIFICATIONS FOR BCP [DISCIPLINE(X) SPECIFIC – X MAY BE I]

BCP/X-01	**INFORMATICS CONCEPTS IN AREA X [1]**	**2-4 CP**

Targeted competencies
- the capability to apply and practise informatics concepts in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …)
- the attitude of appreciation of the relevance of informatics concepts in a specific discipline or area

Learning approaches th ex

Classification

CCS	K.0
UCSI	4

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.
c It is possible that the specific discipline X is informatics itself. In that case this unit can be seen as an extension of BCP-09, emphasizing certain concepts.

BCP/X-02	**INFORMATICS APPLICATIONS IN AREA X [1]**	**2-4 CP**

Targeted competencies
- the skills to elaborate and handle informatics applications in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …)
- the attitude of being self-confident when working with informatics applications in a specific discipline or area

Learning approaches th pr ex

Classification

CCS	J.0	K.0
UCSI	4	

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.
c It is possible that the specific discipline X is informatics itself. In that case this unit can be seen as an extension of BCP-09, emphasizing certain applications.

BCP/X-03 **OPERATING SOFTWARE IN AREA X [2]** **2-4 CP**

Targeted competencies - the skills to effectively work with a software package to be applied in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …, or informatics itself)
- the attitude of aiming at a useful starter's degree of mastering such a software package (or an advanced degree if the software package is the same as in BIP/X-01)

Learning approaches th pr ex

Classification

CCS	J.1-7 K.8.0-1
UCSI	4.2

Notes

a The informatics model curricula do not offer useful references for this unit.

b It is important that a sister department be involved in joint efforts.

c Examples of applications are (in alphabetical order): authoring/educational systems, computer algebra, data mining and marketing, desktop publishing, document management, electronic commerce, electronic democracy, enterprise resource planning (ERP), financial planning, HRM systems, medical systems, multimedia software, scientific computing, simulation, statistical processing, virtual reality, workflow management, …

11 MInor I-Profile (MIP)

Professional categories:

- B2 Interfacing I-appliers
- B3 Researching I-appliers
- B4 Directing I-appliers

CURRICULUM SPECIFICATION OF MIP

Graduate I-profile	**MIP**	**MINOR I-PROFILE**		
Categories of professionals	B2	Interfacing I-appliers		
	B3	Researching I-appliers		
	B4	Directing I-appliers		
		credit points (total)	credit points (generic)	credit points (discipline specific)
Size of educational program	***MIP***	***80***	***64***	***16***
Prerequisites	BIP	20	16	4
	BCP	40	32	8
	Total	**140**	**112**	**28**

Constituting units		*size*	*orien-*	*---------- themes ----------*											
code	*title*	*[cp]*	*tation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
[--- generic --- compulsory ---]															
MIP-01	Context for informatics applications [3]	3-5	AP							x			x		x
MIP-02	Architecture of information systems [2]	3-5	DM	x	x	x		x							
MIP-03	Architecture of software systems [2]	3-5	DM		x		x		x						
MIP-04	Architecture of computer systems [2]	2-4	DM							x	x				
MIP-05	Networking and communication [2]	2-4	DM							x		x	x		
MIP-06	Formalism in information processing [2]	2-4	AP	x	x	x	x			x					
MIP-07	Interaction and presentation [1]	2-4	AP	x			x	x	x	x	x		x	x	
MIP-08	Artificial intelligence [1]	2-4	AP	x			x		x	x					x
MIP-09	Distributed processing and systems [1]	2-4	AP		x	x	x	x	x		x				
MIP-10	Quality and security [1]	2-4	AP			x	x	x	x		x	x	x		x
MIP-11	Acting as a professional [1]	2-4	AP					x	x	x			x	x	x
MIP-12	Modelling and system development [2]	4-6	DM			x		x						x	
MIP-13	Software development [1]	4-6	DM				x		x					x	
MIP-14	Miscellaneous / state-of-the-art [2]	3-5	AP							x					x
[---generic --- elective for B2/B3/B4 ---]		*5-7*	AP											x	x
MIP-15/B2	Communication in the I-area														
MIP-15/B3	Methodology in I-related research														
MIP-15/B4	Management in the I-area														
[--- discipline(X) specific --- X may be I ---]															
MIP/X-01	Informatics concepts in area X [2]	3-5	AP	x	x	x	x	x	x					x	x
MIP/X-02	Informatics applications in area X [2]	3-5	AP							x			x		x
MIP/X-03	Operating software in area X [3]	3-5	DM							x				x	x
MIP/X-04	System development in area X [1]	3-5	DM			x	x	x	x					x	x
[--- generic --- different for B2/B3/B4 ---]															
MIP-16/Bx	Mini project	8-12	DM											x	x
	Total size & theme 'fingerprint'	**80**	**DM [AP]**	**5**	**5**	**7**	**8**	**8**	**9**	**10**	**4**	**3**	**5**	**9**	**12**

1 credit point [cp] = 1 day of study

Orientation:

AW *AWareness (know or use):*
Aiming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages;

AP *APplication:*
Aiming at developing a basic conceptual understanding of informatics and of some more advanced informatics skills which allow students to apply basic informatics to other disciplines or areas.

DM *Design and Modelling:*
Aiming at developing a general understanding and broad overview of informatics, especially with respect to the modelling and the design of informatics applications.

Themes

1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;
8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

UNIT SPECIFICATIONS FOR MIP [GENERIC - COMPULSORY]

MIP-01	**CONTEXT FOR INFORMATICS APPLICATIONS [3]**	**3-5 CP**

Targeted competencies
- the capability to account for certain contextual aspects (business-wise, societal, individual, technical, managerial and historical) in the use and design of informatics applications
- the attitude of being self-confident with respect to the inclusion of contextual aspects associated with informatics applications

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units SP1-3 SU25
>>>	***IS97***	**Courses 1C-D,F-G,L 2A-G 3A,C,E-H,K,M**
	ISCC99	Courses 11 22 44

Classification

	CCS	J.0 K.1-2,3.0-7.0
	UCSI	4.1-4

MIP-02	**ARCHITECTURE OF INFORMATION SYSTEMS [2]**	**3-5 CP**

Targeted competencies
- the capability to model and design simple, small-sized information systems, databases or knowledge-based systems (or components of larger systems)
- the attitude of being self-confident with respect to the process of designing information systems in general

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units DB SU11
>>>	***IS97***	**Courses 1A-B,E,J 2J 3A,C-D,F-G 7A,J 8A-C**
	ISCC99	Courses 11 21/1.041/1.0-3.0 61/1.0-5.0

Classification

	CCS	H.1.0-4.0
	UCSI	3.1 3.2 3.3

MIP-03	**ARCHITECTURE OF SOFTWARE SYSTEMS [2]**	**3-5 CP**

Targeted competencies - the capability to specify and design simple, small-sized computer programs (or components of larger programs)
- the attitude of being self-confident with respect to the process of designing computer programs in general

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units**	**AL**	**PL**	**SE**
	IS97	Courses 1H-I	2G-H	5	9B-C
	ISCC99	Course 31/1.0-2.0			

Classification

	CCS	D.1.0-3.0 E.1
	UCSI	2.1 2.2 2.3

MIP-04	**ARCHITECTURE OF COMPUTER SYSTEMS [2]**	**2-4 CP**

Targeted competencies - the capability to reproduce and interpret parts of the functional model of computer systems and of the functioning of operating systems
- the attitude of being self-confident with respect to computer systems and operating systems in a functional way

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units**	**AR**	**OS**
	IS97	Course 4A-H		
	ISCC99	Course 21/4.0		

Classification

	CCS	B.0	C.1.0,5.0	D.4.0
	UCSI	1.1-3	1.5	

MIP-05	**NETWORKING AND COMMUNICATION [2]**	**2-4 CP**

Targeted competencies
- the capability to reproduce and interpret parts of the functional model of networks and of the communication function in various technical infrastructures
- the attitude of being self-confident with respect to networking and electronic communication in a functional way

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units AR6 OS9 SU7
>>>	***IS97***	**Courses 1K 3J-K 4G 6**
	ISCC99	Courses 21/2.042

Classification

	CCS	B.4.0 C.2.0
	UCSI	1.4

MIP-06	**FORMALISM IN INFORMATION PROCESSING [2]**	**2-4 CP**

Targeted competencies with
- the capability to basically manipulate in a selected set of formalisms

  respect to both computing and information, including mathematical reasoning by using logic
- the attitude of being self-confident with respect to low-level formal manipulation and of recognising the possible relevance of formal approaches

Learning approaches th ex

Curriculum references

>>>	***CC91***	**Knowledge units AL4-5,7 PL7-10 SU3,6,14,24,27**
	IS97	Courses 1A-B 3D 5G
	ISCC99	Course 31

Classification

	CCS	E.4 F.0 H.1.0
	UCSI	2.5 3.5

MIP-07 **INTERACTION AND PRESENTATION [1]** **2-4 CP**

Targeted competencies
- the capability to understand and describe the main issues and methods in areas like human-computer interaction, user interfaces, computer graphics, multimedia, ergonomics
- the attitude of appreciation of the relevance of interaction and presentation aspects associated with informatics applications

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units	HU	SU8-9
	IS97	Courses 2I	3I,K	8F
	ISCC99	Course 43		
>>>	***HCI92***	**Courses CS1**	**CS2**	**PSY1**

Classification

	CCS	H.5.0 I.3.0-4.0
	UCSI	3.4

MIP-08 **ARTIFICIAL INTELLIGENCE [1]** **2-4 CP**

Targeted competencies
- the capability to understand and describe the main issues and methods in areas like artificial intelligence, robotics, knowledge representation, expert systems
- the attitude of appreciation of the relevance of concepts and applications from the area of artificial intelligence for the informatics discipline

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units AI**	**SU4,23**
	ISCC99	Course EL/T/2.0,4.0	

Classification

	CCS	I.2.0
	UCSI	2.4

MIP-09	**DISTRIBUTED PROCESSING AND SYSTEMS [1]**	**2-4 CP**

Targeted competencies
- the capability to understand and describe the main issues in distributed processing and systems, regarding computer architectures, computer programming and information systems
- the attitude of appreciation of the relevance of distributed (as compared to the more conventional stand-alone) processing and systems

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units AL9 AR7 OS10 PL12 SU17**
	IS97	Course 6G
>>>	***ISCC99***	**Courses 21/3.0 51**

Classification

	CCS	C.1.4,2.4 D.1.3
	UCSI	1.92.93.9

MIP-10	**QUALITY AND SECURITY [1]**	**2-4 CP**

Targeted competencies
- the capability to understand and describe the main issues related to quality and security of informatics applications, stretching from technical to organisational matters
- the attitude of appreciation of the need to include quality and security aspects associated with informatics applications

Learning approaches th ex

Curriculum references

	CC91	Knowledge units OS8 SU10
>>>	***IS97***	**Courses 1C 3B 6K 7K 9D**

Classification

	CCS	D.4.6 E.3 K.6.5
	UCSI	1.5.9 2.3.9 2.5.4 3.3.9 4.1.3 4.4.3

MIP-11 **ACTING AS A PROFESSIONAL [1]** **2-4 CP**

Targeted competencies
- the capability to explain the major characteristics of professional acting in the informatics field in general (responsibility, liability, quality, planning and control, customer orientation, code of ethics, certification, …) and to understand the role as a manager of informatics projects more specifically
- the attitude of appreciation of the need for professional acting in general and of the role of an informatics project manager more specifically

Learning approaches th ex

Curriculum references

	CC91	Knowledge unit		SP					
>>>	***IS97***	**Courses**	**1C-D,L**	**2B-F,K**	**3B,G-H,J,M**		**7A-F,N**		**10**
>>>	***ISCC99***	**Courses**	**22**	**32**	**44**	**61**	**EL/O/3.0**		

Classification

	CCS	K.4-7	
	UCSI	4.14.3.3	4.4

MIP-12 **MODELLING AND SYSTEM DEVELOPMENT [2]** **4-6 CP**

Targeted competencies
- the capability to contribute partly to the development and engineering of information systems according to a selected approach, methodology or tool set
- the attitude of being self-confident with respect to the engineering of information systems

Learning approaches th pr ex [rl]

Curriculum references

	CC91	Knowledge unit		DB					
>>>	***IS97***	**Courses**	**1E-G**	**2G,J**	**3A-H**	**7**	**8**	**10**	
>>>	***ISCC99***	**Courses**	**11**	**21**	**41**	**44**	**61**		
	HCI92	Course	MIS1						

Classification

	CCS	H.0	
	UCSI	3.1-2	3.3.1-4

MIP-13 **SOFTWARE DEVELOPMENT [1]** **4-6 CP**

Targeted competencies
- the capability to contribute partly to the design and engineering of software according to a selected approach, methodology or tool set
- the attitude of being self-confident with respect to the engineering of software

Learning approaches th pr ex [rl]

Curriculum references

>>>	***CC91***	**Knowledge units**	**AL**	**PL**	**SE1-5SU2**	
	IS97	Courses 1H-I	5	7H,K	9A-E,I-K	10
	ISCC99	Courses 31	61			

Classification

	CCS	D.1.0,3.0 D.2.1-13
	UCSI	2.1-2 2.3.1-4

MIP-14 **MISCELLANEOUS / STATE-OF-THE-ART [2]** **3-5 CP**

Targeted competencies
- the capability to understand and describe the main issues and methods in one or more state-of-the-art areas not being covered by one of the compulsory units
- the attitude of appreciation of the relevance of new developments

Learning approaches th pr ex

Notes

a There is no reason to specifically refer to model curricula for this unit or to classify it.
b This unit typically has a very dynamic content (it may change every year or even semester).
c The unit may also vary with respect to the categories of professionals B2, B3 and B4.

UNIT SPECIFICATIONS FOR MIP [GENERIC – ELECTIVE FOR B2, B3, B4]

MIP-15/B2 **COMMUNICATION IN THE I-AREA** **5-7 CP**

Targeted competencies
- the capability to understand and practise the main issues, methods and techniques that are important with respect to human communication in a variety of appearances in the informatics area
- the attitude of growing into an informatics applying interfacing professional

Learning approaches th pr ex

Curriculum references

IS97	Courses	7B-C	10E-F,H-J
ISCC99	Course	44	

Classification

CCS	K.4.0
UCSI	4.4

Notes

a The really relevant curriculum references and classification originate not from the informatics discipline, but from the communication area.

MIP-15/B3 **METHODOLOGY IN I-RELATED RESEARCH** **5-7 CP**

Targeted competencies
- the capability to understand and practise methodological matters in interdisciplinary research (related to informatics)
- the attitude of growing into an informatics applying researching professional

Learning approaches th pr ex

Curriculum references

No specifics

Classification

No specifics

Notes

a Relevant curriculum references and classification originate not from the informatics discipline, but from the research methodology field.

MIP-15/B4	**MANAGEMENT IN THE I-AREA**	**5-7 CP**

Targeted competencies
- the capability to understand and practise the main issues, methods and techniques that are important with respect to management (in a broad sense) in the informatics area
- the attitude of growing into an informatics applying directing professional

Learning approaches th pr ex

Curriculum references

>>>	***IS97***	**Courses**	**1C-D**	**2A-E,K**	**3A-H,J-L**	**6N**	**8H**	**10**
	ISCC99	Course	44					

Classification

CCS	K.6.0
UCSI	4.1

Notes

a More relevant curriculum references and classification originate not from the informatics discipline, but from the management area.

UNIT SPECIFICATIONS FOR MIP [DISCIPLINE(X) SPECIFIC – X MAY BE I]

MIP/X-01 **INFORMATICS CONCEPTS IN AREA X [2]** **3-5 CP**

Targeted competencies
- the capability to apply and practise informatics concepts in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …)
- the attitude of appreciation of the relevance of informatics concepts in a specific discipline or area

Learning approaches th ex

Classification

CCS	K.0
UCSI	4

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.
c It is possible that the specific discipline X is informatics itself. In this case this unit can be seen as an extension of MIP-14, emphasizing specific concepts.

MIP/X-02 **INFORMATICS APPLICATIONS IN AREA X [2]** **3-5 CP**

Targeted competencies
- the skills to elaborate and handle informatics applications in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …)
- the attitude of being self-confident when working with informatics applications in a specific discipline or area

Learning approaches th pr ex

Classification

CCS	J.0	K.0
UCSI	4	

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.
c It is possible that the specific discipline X is informatics itself. In this case this unit can be seen as an extension of MIP-14, emphasizing specific applications.

MIP/X-03 **OPERATING SOFTWARE IN AREA X [3]** **3-5 CP**

Targeted competencies
- the skills to effectively make applications with a software package that is meant for a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …, or informatics itself)
- the attitude of aiming at an adequate degree of mastering such a software package

Learning approaches th pr ex [rl]

Classification

CCS	J.1-7	K.8.0-1
UCSI	4.2	

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.

MIP/X-04 **SYSTEM DEVELOPMENT IN AREA X [1]** **3-5 CP**

Targeted competencies
- the capability to contribute partly to the development and engineering of software or information systems meant for a specific area
- the attitude of being self-confident with respect to system development in a specific area

Learning approaches th pr ex [rl]

Classification

CCS	D.0	H.0	J.1-7
UCSI	2.33.34.2		

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.

UNIT SPECIFICATIONS FOR MIP [GENERIC – DIFFERENT FOR B2, B3, B4]

MIP-16/BX	**MINI-PROJECT**	**8-12 CP**

Targeted competencies
- the capability to individually run a small project that builds upon competencies achieved earlier in the MIP graduate profile and that relates to one of the three categories of informatics appliers: interfacing (B2), researching (B3) or directing (B4)
- the attitude of finalising the profile of a professional informatics applier (interfacing, researching or directing)

Learning approaches th pr rl

Notes

a There is no reason to specifically refer to model curricula for this unit or to classify it.
b This unit is the final unit of the MIP graduate profile.
c The unit varies with respect to the categories of professionals B2, B3 and B4.

12 MAjor I-Profile (MAP)

Professional categories:

- C1 Operational I-workers
- C2 Engineering I-workers
- C3 Researching I-workers

CURRICULUM SPECIFICATION OF MAP

Graduate I-profile	**MAP**	**MAJOR I-PROFILE**		
Categories of professionals	C1	Operational I-workers		
	C2	Engineering I-workers		
	C3	Researching I-workers		

		credit points (total)	credit points (generic)	credit points (discipline specific)
Size of educational program	***MAP***	***160***	***128***	***32***
Prerequisites	BIP	20	16	4
	BCP	40	32	8
	MIP	80	64	16
	Total	**300**	**240**	**60**

Constituting units		*size*	*orien-*	*themes*										
code	*title*	*[cp]*	*tation*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
[--- generic --- compulsory ---]															
MAP-01	Context for informatics applications [4]	5-7	CA						x			x		x	
MAP-02	Architecture of information systems [3]	7-9	CAx	x	x		x								
MAP-03	Architecture of software systems [3]	7-9	CA	x		x		x							
MAP-04	Architecture of computer systems [3]	5-7	CA						x	x					
MAP-05	Networking and communication [3]	5-7	CA						x		x	x			
MAP-06	Formalism in information processing [3]	7-9	CAx	x	x	x			x						
MAP-07	Interaction and presentation [2]	7-9	DM	x			x	x	x	x	x		x	x	
MAP-08	Artificial intelligence [2]	5-7	DM	x			x		x	x					x
MAP-09	Distributed processing and systems [2]	5-7	DM	x	x	x	x	x		x					
MAP-10	Quality and security [2]	5-7	AP			x	x	x	x		x	x	x		x
MAP-11	Acting as a professional [2]	5-7	DM					x	x	x			x	x	x
MAP-12	Modelling and system development [3]	7-9	DM			x		x						x	
MAP-13	Software development [2]	7-9	DM				x		x					x	
MAP-14	Miscellaneous / state-of-the-art [3]	3-5	CA						x					x	
[---generic --- elective for C1/C2/C3 ---]		*9-11*	AP											x	x
MAP-15/C1	Operational aspects in the I-area														
MAP-15/C2	Engineering principles for I-systems														
MAP-15/C3	Methodology in I-research														
[--- discipline(X) specific --- X may be I ---]															
MAP/X-01	Informatics concepts in area X [3]	7-9	CAx	x	x	x	x	x					x	x	
MAP/X-02	Informatics applications in area X [3]	7-9	AP							x			x		x
MAP/X-03	Operating software in area X [4]	7-9	DM							x				x	x
MAP/X-04	System development in area X [2]	7-9	DM			x	x	x	x					x	x
[--- generic --- different for C1/C2/C3 ---]															
MAP-16/Cx	Final project	24-32	DM											x	x
	Total size & theme 'fingerprint'	**160**	**CA [DM]**	**5**	**5**	**7**	**8**	**8**	**9**	**10**	**4**	**3**	**5**	**9**	**12**

1 credit point [cp] = 1 day of study

Orientation:

AW *AWareness (know or use):*
*A*iming at developing basic knowledge as well as skills that allow students to act basically literate with respect to informatics in general and to perform standard operations using computer technology or software packages;

AP *APplication:*
*A*iming at developing a basic conceptual understanding of informatics and of some more advanced informatics skills which allow students to apply basic informatics to other disciplines or areas;

DM *Design and Modelling:*
*A*iming at developing a general understanding and broad overview of informatics, especially with respect to the modelling and the design of informatics applications;

CA *Conceptualisation and Abstraction:*
Aiming at developing a thorough understanding of and well-developed skills in informatics as a broad discipline, the essence being to further develop the capability of students to abstract and to conceptualise.

Themes

1 Representation of information;
2 Formalism in information processing;
3 Information modelling;
4 Algorithmics;
5 System design;
6 Software development;
7 Potentials and limitations of computing and related technologies;
8 Computer systems and architectures;
9 Computer-based communication;
10 Social and ethical implications;
11 Personal and interpersonal skills;
12 Broader perspectives and context (including links with other disciplines).

UNIT SPECIFICATIONS FOR MAP [GENERIC - COMPULSORY]

MAP-01 **CONTEXT FOR INFORMATICS APPLICATIONS [4]** **5-7 CP**

Targeted competencies
- the capability to include contextual aspects (business-wise, societal, individual, technical, managerial and historical), both conceptually and pragmatically, in the use and design of informatics applications
- the attitude of having a vision on the inclusion of contextual aspects associated with informatics applications

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units SP1-3 SU25
>>>	***IS97***	**Courses 1C-D,F-G,L 2A-G 3A,C,E-H,K,M**
	ISCC99	Courses 11 22 44

Classification

CCS	J.0 K.1-2,3.0-7.0
UCSI	4.1-4

MAP-02 **ARCHITECTURE OF INFORMATION SYSTEMS [3]** **7-9 CP**

Targeted competencies
- the capability to model and design moderately complex, small-sized information systems, databases or knowledge-based systems (or components of larger systems)
- the attitude of mastering the design process of information systems, from both a conceptual and a pragmatic point of view

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units DB SU11
>>>	***IS97***	**Courses 1A-B,E,J 2J 3A,C-D,F-G 7A,J 8A-E**
	ISCC99	Courses 11 21/1.041/1.0-6.0 61/1.0-5.0

Classification

CCS	H.1.0-4.0
UCSI	3.1 3.2 3.3

MAP-03	**ARCHITECTURE OF SOFTWARE SYSTEMS [3]**	**7-9 CP**

Targeted competencies
- the capability to specify and design moderately complex, small-sized computer programs (or components of larger programs)
- the attitude of mastering the design process of computer programs, from both a conceptual and a pragmatic point of view

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units**	**AL**	**PL**	**SE**	
	IS97	Courses	1H-I	2G-H	5	9B-C
	ISCC99	Course	31/1.0-2.0			

Classification

	CCS	D.1.0-3.0 E.1
	UCSI	2.1 2.2 2.3

MAP-04	**ARCHITECTURE OF COMPUTER SYSTEMS [3]**	**5-7 CP**

Targeted competencies
- the capability to reproduce and interpret the functional model of computer systems as a whole and of the full functioning of operating systems
- the attitude of mastering the functional view on computer systems and the functioning of operating systems

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units**	**AR**	**OS**	
	IS97	Course	4A-H		
	ISCC99	Course	21/4.0		

Classification

	CCS	B.0 C.1.0,5.0 D.4.0
	UCSI	1.1-3 1.5

MAP-05 **NETWORKING AND COMMUNICATION [3]** **5-7 CP**

Targeted competencies
- the capability to reproduce and interpret the functional model of networks as a whole and of the full communication function in various technical infrastructures
- the attitude of mastering the functional view on networking and electronic communication

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units AR6 OS9 SU7
>>>	***IS97***	**Courses 1K 3J-K 4G 6**
	ISCC99	Courses 21/2.042

Classification

	CCS	B.4.0 C.2.0
	UCSI	1.4

MAP-06 **FORMALISM IN INFORMATION PROCESSING [3]** **7-9 CP**

Targeted competencies
- the capability to understand formal concepts and manipulate in formalisms with respect to both computing and information, including mathematical reasoning by using logic
- the attitude of mastering formal approaches

Learning approaches th ex

Curriculum references

>>>	***CC91***	**Knowledge units AL4-5,7 PL7-10 SU3,6,14,24,27**
	IS97	Courses 1A-B 3D 5G
	ISCC99	Course 31

Classification

	CCS	E.4 F.0 H.1.0
	UCSI	2.5 3.5

MAP-07 **INTERACTION AND PRESENTATION [2]** **7-9 CP**

Targeted competencies
- the capability to specify and design simple components for human-computer interaction or graphical user interfaces
- the attitude of being self-confident with respect to incorporating interaction and presentation aspects when designing computer programs or information systems

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units	HU	SU8-9
	IS97	Courses 2I	3I,K	8F
	ISCC99	Course 43		
>>>	***HCI92***	**Courses CS1**	**CS2**	**PSY1**

Classification

	CCS	H.5.0 I.3.0-4.0
	UCSI	3.4

MAP-08 **ARTIFICIAL INTELLIGENCE [2]** **5-7 CP**

Targeted competencies
- the capability to specify and design simple artificial intelligence applications (or components of larger applications)
- the attitude of being self-confident with respect to the positioning of artificial intelligence applications in the broad computer programming field

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units AI**		**SU4,23**
	ISCC99	Course EL/T/2.0,4.0		

Classification

	CCS	I.2.0
	UCSI	2.4

MAP-09 **DISTRIBUTED PROCESSING AND SYSTEMS [2]** **5-7 CP**

Targeted competencies
- the capability to specify and design simple distributed systems
- the attitude of being self-confident with respect to the concept of distributed processing and to the distribution of systems

Learning approaches th pr ex

Curriculum references

>>>	***CC91***	**Knowledge units AL9 AR7 OS10 PL12 SU17**
	IS97	Course 6G
>>>	***ISCC99***	**Courses 21/3.0 51**

Classification

CCS	C.1.4,2.4 D.1.3
UCSI	1.92.93.9

MAP-10 **QUALITY AND SECURITY [2]** **5-7 CP**

Targeted competencies
- the capability to account for quality and security aspects when designing or using informatics applications
- the attitude of being self-confident with respect to the attention for quality and security related to informatics applications

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge units OS8 SU10
>>>	***IS97***	**Courses 1C 3B 6K 7K 9D**

Classification

CCS	D.4.6 E.3 K.6.5
UCSI	1.5.9 2.3.9 2.5.4 3.3.9 4.1.3 4.4.3

MAP-11	**ACTING AS A PROFESSIONAL [2]**	**5-7 CP**

Targeted competencies
- the capability to manifest oneself as a professional in the informatics area, more specifically in the role of a manager of informatics projects
- the attitude of wishing to act as a professional in the informatics area

Learning approaches th pr ex

Curriculum references

	CC91	Knowledge unit		SP					
>>>	***IS97***	**Courses**	**1C-D,L**	**2B-F,K**	**3B,G-H,J,M**		**7A-F,N**		**10**
>>>	***ISCC99***	**Courses**	**22**	**32**	**44**	**61**	**EL/O/3.0**		

Classification

	CCS	K.4-7
	UCSI	4.14.3.3 4.4

MAP-12	**MODELLING AND SYSTEM DEVELOPMENT [3]**	**7-9 CP**

Targeted competencies
- the capability to contribute substantially to the development and engineering of information systems according to a selected (possibly mixed) approach, methodology or tool set
- the attitude of mastering the engineering process of information systems

Learning approaches th pr ex rl

Curriculum references

	CC91	Knowledge unit		DB					
>>>	***IS97***	**Courses**	**1E-G**	**2G,J**	**3A-H**	**7**	**8**	**10**	
>>>	***ISCC99***	**Courses**	**11**	**21**	**41**	**44**	**61**		
	HCI92	Course	MIS1						

Classification

	CCS	H.0
	UCSI	3.1-2 3.3.1-4

MAP-13 **SOFTWARE DEVELOPMENT [2]** **7-9 CP**

Targeted competencies - the capability to contribute substantially to the design and engineering of software according to a selected (possibly mixed) approach, methodology or tool set
- the attitude of mastering the engineering process of software

Learning approaches th pr ex rl

Curriculum references

>>>	***CC91***	**Knowledge units**	**AL**	**PL**	**SE1-5SU2**
	IS97	Courses 1H-I	5	7H,K	9A-E,I-K 10
	ISCC99	Courses 31	61		

Classification

	CCS	D.1.0,3.0 D.2.1-13
	UCSI	2.1-2 2.3.1-4

MAP-14 **MISCELLANEOUS / STATE-OF-THE-ART [3]** **3-5 CP**

Targeted competencies - the capability to understand and describe the main new concepts in one or more state-of-the-art areas not being covered by one of the compulsory units
- the attitude of appreciation of the relevance of newly developed concepts

Learning approaches th pr ex

Notes

a There is no reason to specifically refer to model curricula for this unit or to classify it
b This unit typically has a very dynamic content (it may change every year or even semester).
c The unit may also vary with respect to the categories of professionals C1, C2 and C3.

UNIT SPECIFICATIONS FOR MAP [GENERIC – ELECTIVE FOR C1, C2, C3]

MAP-15/C1 **OPERATIONAL ASPECTS IN THE I-AREA** **9-11 CP**

Targeted competencies
- the capability to understand and practise the main issues, methods and techniques that are important with respect to the operation of a variety of informatics applications
- the attitude of growing into an operational informatics professional

Learning approaches th pr ex

Curriculum references

IS97	Courses	3J	6N	9H-J
ISCC99	Course	44		

Classification

UCSI	1.4.4	2.3.3	3.3.3	4.1.2

Notes

a The curriculum references and classification are weak for this particular unit.

MAP-15/C2 **ENGINEERING PRINCIPLES FOR I-SYSTEMS** **9-11 CP**

Targeted competencies
- the capability to understand and practise general engineering principles with respect to the development of informatics systems
- the attitude of growing into an engineering informatics professional

Learning approaches th pr ex

Curriculum references

No specifics

Classification

No specifics

Notes

a Relevant curriculum references and classification originate from the engineering field.

MAP-15/C3	**METHODOLOGY IN I-RESEARCH**	**9-11 CP**

Targeted competencies
- the capability to understand and practise methodological matters in informatics research
- the attitude of growing into a researching informatics professional

Learning approaches th pr ex

Curriculum references
No specifics

Classification
No specifics

Notes
a Relevant curriculum references and classification originate from the research methodology field.

UNIT SPECIFICATIONS FOR MAP [DISCIPLINE(X) SPECIFIC – X MAY BE I]

MAP/X-01 **INFORMATICS CONCEPTS IN AREA X [3]** **7-9 CP**

Targeted competencies
- the capability to analyse and interpret informatics concepts in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …)
- the attitude of being self-confident with respect to informatics concepts in a specific discipline or area

Learning approaches th ex

Classification

CCS	K.0
UCSI	4

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.
c It is possible that the specific discipline X is informatics itself. In this case this unit can be seen as an extension of MAP-14, emphasizing specific concepts.

MAP/X-02 **INFORMATICS APPLICATIONS IN AREA X [3]** **7-9 CP**

Targeted competencies
- the skills to elaborate and handle informatics applications in a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …)
- the attitude of being self-confident when working with informatics applications in a specific discipline or area

Learning approaches th pr ex

Classification

CCS	J.0	K.0
UCSI	4	

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.
c It is possible that the specific discipline X is informatics itself. In this case this unit can be seen as an extension of MAP-14, emphasizing specific applications.

MAP/X-03 **OPERATING SOFTWARE IN AREA X [4]** **7-9 CP**

Targeted competencies
- the skills to effectively make applications with a software package that is meant for a specific discipline or area (like economics, business administration, mathematics, science, engineering, medicine, education, law, psychology, arts, linguistics, philosophy, social sciences, …, or informatics itself)
- the attitude of aiming at an adequate degree of mastering such a software package

Learning approaches th pr ex rl

Classification

CCS	J.1-7 K.8.0-1
UCSI	4.2

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.

MAP/X-04 **SYSTEM DEVELOPMENT IN AREA X [2]** **7-9 CP**

Targeted competencies
- the capability to contribute substantially to the development and engineering of software or information systems meant for a specific area
- the attitude of being self-confident with respect to system development in a specific area

Learning approaches th pr ex rl

Classification

CCS	D.0 H.0 J.1-7
UCSI	2.33.34.2

Notes

a The informatics model curricula do not offer useful references for this unit.
b It is important that a sister department be involved in joint efforts.

UNIT SPECIFICATIONS FOR MAP [GENERIC – DIFFERENT FOR C1, C2, C3]

MAP-16/CX	**FINAL PROJECT**	**24-32 CP**

Targeted competencies

- the capability to run a project (individual or as a team) that integrates among competencies achieved earlier in the MAP graduate profile and that relates to one of the three categories of informatics professionals: operational (C1), engineering (C2) or researching (C3)
- the attitude of finalising the profile of an informatics professional (operational, engineering or researching)

Learning approaches th pr rl

Notes

a There is no reason to specifically refer to model curricula for this unit or to classify it.
b This unit is the final unit in the MAP graduate profile.
c Contents of the unit vary with respect to the categories of professionals C1, C2 and C3.

13 Keeping ICF-2000 up to date

Developments in the field of informatics are very fast. The content of informatics education is changing continuously. This means that curricula and study materials have to be updated all the time. Much effort is put into this updating by professional bodies, educational institutions and publishers. The ICF-2000 curriculum framework has also to be regularly kept up to date. ICF-2000 is designed in such a way that this updating can be done relatively easily and in a cost-effective way. However, there is need for an updating mechanism to assure that updating is done timely and regularly.

UPDATING ICF-2000

ICF-2000 is a framework that refers educational managers, curriculum developers and developers of study materials to major, widely accepted and widely implemented, informatics model curricula and associated resources. Much effort is put into keeping these model curricula up to date and new model curricula are being developed. Moreover a wide variety of curriculum experiences is gained at universities all over the world. Also market players are getting more involved in curriculum development through specifying professional profiles based on market demands. These developments all have to be reflected in the curriculum framework and result in updates of ICF-2000.

Updating for revised curricula
Let us take the ACM/IEEE-CS Computing Curriculum '91 as an example. It is currently under revision. The revised curriculum is expected to be published in 2001. When the new version of the curriculum is available ICF-2000 has to be brought up to date with this new version. This implies that the appendix describing ACM Curriculum '91 has to be updated to reflect the new ACM/IEEE-CS Curriculum 2001. And in ICF-2000 itself references to this appendix have to be updated and possibly extended. If ACM/IEEE-CS Curriculum 2001 implies a major curriculum revision also ICF-2000 curriculum specifications will have to be updated and unit specifications added and modified.

Adding new curricula
New curricula may also be added to the framework. For example, IEEE-CS and ACM are working on a curriculum for software engineering. To incorporate this new curriculum in ICF-2000 a summary of the new curriculum has to be added to ICF-2000 in an appendix. Within ICF-2000 itself references to this appendix have to be added where appropriate. Also ICF-2000 curriculum specifications will have to be updated and unit specifications added and modified.

Incorporating curriculum experiences
Experiences in universities with respect to either development or implementation of curricula could lead to reviews of ICF-2000 and revisions of its contents. This should be facilitated by a constant flow of information through an extensive contact network of universities all over the world.

Accounting for changing market demands
Regular reviews of ICF-2000 are indicated with respect to market demands. The relation between ICF-2000 professional categories (see Chapter 4) and expert profiles specified by market players has to be regularly reviewed for completeness and appropriateness. A well-organized interaction with market players is essential to include such changes adequately.

Staying in line with informatics developments
The framework ICF-2000 itself is considered to be state of the art. In view of the rapid developments in the field of informatics a major revision of the framework is indicated at least every seven years. Through its working groups IFIP is ideally equipped to keep track of major developments and their consequences for ICF-2000.

SUPPORT FOR ICF-2000 FROM MARKET PLAYERS

Support for the implementation of ICF-2000 in both developed and developing countries, may be solicited by UNESCO from market players.

Developed countries
We would like to refer to a recent interesting initiative by seven major European companies in the field of ICT (Information and Communication Technology). These companies are: British Telecommunications, IBM Europe, Microsoft Europe, Nokia Telecommunicatons, Philips Semiconductors, Siemens AG and Thomson CSF. They have joined the European Commission to work towards closing the ICT skills gap in Europe (see Addendum).
We quote from a press release, dated on November 25, 1999:

> *As the first concrete step the ICT consortium has created a number of generic job profiles to put in place a clear framework that describes the skills and competencies required by the ICT industry, the ladder for career progression, and the qualifications and training required. To date, the consortium has compiled thirteen generic job profiles relevant to the companies' main activities. These profiles, as well as other related information about the activities of the ICT industry are now available on a dedicated website at http://www.career-space.com*
> *"One of the fundamental problems the European workforce faces today is a lack of cohesion in the way industry defines ICT skills, qualifications and job profiles", says the chairman of ICT Consortium, Richard Straub, IBM Director of Learning. "The Generic Skills Profile Project offers a practical basis for improved co-operation between industry, educational institutions and individuals whilst also providing a set of criteria for helping education authorities in Member States in their efforts to tailor curricula to the digital economy."*
> *In order to increase the short and long-term availability of skilled people the ICT Consortium has developed a list of recommendations. The Consortium recommends the establishment of a Task Force comprising of industry, educational institutions, the European Commission and the member states to examine, how they can work in partnership to meet Europe's industrial and social needs, and to implement appropriate actions.*
> *Understanding and using ICT will increasingly be a crucial life skill - those without it will increasingly loose out on speed and availability of access to a range of services. ICT literacy should be treated as a core part of school curricula in the same way as reading and writing and students should be encouraged to use ICT both in curricula and outside activities. All education professionals should be ICT literate and actively work to attract students - especially girls - into mathematics, science, engineering and other ICT relevant courses, positively representing the wide-ranging opportunities available within the ICT sector.*

This clearly shows that large ICT oriented companies strongly push for a substantial increase of their influence on education in the area of informatics (or ICT) in general, from primary school to university. This attitude can be understood in a broader context of sincere concern over the large and growing shortage of ICT skilled people in the European workforce. The consortium of the seven ICT companies considers the situation as a major challenge which, if not addressed properly, represents a threat not only to the development of the ICT industry in Europe, but also to the social well-being and competitiveness of the whole European economy.

This European initiative shows the readiness and commitment of the large ICT companies to give full support, also financially in public-private partnerships, to a process that concentrates strongly on improving the quality and enhancing the quantity of ICT workers in a broad sense. This development relates directly to informatics education and it creates a need for clarity of the full picture, ranging from the profile of ICT worker to the curriculum units needed to educate this worker; a full picture such as presented by ICF-2000. The situation described here is not at all typical for Europe only, it is rather of a global nature. This situation offers UNESCO the opportunity to seek alliances that make an impact, to generate commitment and to succour financial support (e.g. by sponsorships or project adoption).

Developing countries

Important suppliers of hardware and software, like Apple, Compaq, Hewlett-Packard, IBM, Intel, Microsoft, Oracle, Sun, etc. should be invited to supply information on new products (in particular those parts of their training programmes in which new products are introduced) to higher education institutions. This would help to facilitate implementation of ICF-2000 based curricula. Further sponsoring might be considered, not only from hardware and software suppliers, but also from the ICT service industry, the telecom industry, Internet service providers, or even big 'users' such as banks and insurance companies.

PROPOSAL FOR A MECHANISM FOR UPDATING ICF-2000

ICF-2000 is designed in such a way that updating can be done relatively easily and in a cost-effective way. There is need for an updating mechanism to assure that updating is done timely and regularly. Such an updating mechanism should provide for the following activities, involving participants as indicated:

- updating for revised curricula [professional organizations]
- adding new curricula [professional organizations]
- incorporating curriculum experiences [universities]
- accounting for changing market demands [market players]
- staying in line with informatics developments [IFIP]
- overall facilitation [UNESCO supported by IFIP]

The updating mechanism should be based on a network of professional organizations, universities and market players and be facilitated by UNESCO, possibly through the intervention of IFIP. The network might involve organizations and institutions as mentioned below.

Professional organizations, such as:

- Association for Computing Machinery (ACM);
- Computer Society of the Institute of Electrical and Electronics Engineers (IEEE-CS);
- Association of Information Technology Professionals (AITP);
- Association for Information Systems (AIS);
- European Computer Driving Licence Foundation (ECDL), or its international counterpart (ICDL);
- ……. (other non-US based organizations, including IFIP).

Higher education institutions (universities) from:

- United States;
- Western Europe;
- Eastern Europe;
- Russia;
- China;
- Africa;
- Asia;
- South-America.

Large market players, for example a selection from:

- Apple;
- AT&T;
- British Telecom;
- Cap Gemini;
- Compaq;
- Computer Associates;

- Deutsche Telekom;
- EDS;
- Ericsson;
- General Electric;
- Hewlett-Packard;
- IBM;
- Intel;
- Microsoft;
- Nokia;
- Oracle;
- Philips;
- Siemens;
- Sun;
- Thomson CSF;
- World Online;
- ……. (other market players, such as big 'users', e.g. banks, insurance companies).

Facilitators:
- UNESCO;
- IFIP and its Working Groups.

INSTRUMENTS

The following instruments can be used to facilitate this network of professional organizations, universities and market players.

Co-operation via the Internet
Participants in the network should co-operate over the Internet on issues related to the updating of ICF-2000 and the implementation of ICF-2000. A clear working agenda should be agreed upon for this co-operation to become a success. Professional organizations, universities, market players, and IFIP Working Groups should contribute to this co-operation via the Internet. It might be worthwhile to get in touch with new emerging institutions such as the British University for Industry and the Dutch ICT Networking Academy (still under development), that are strongly Internet oriented and aim at a good match between industry and higher education.
Benefits can be gained from the use of the Internet, both for systematic information gathering and communication between the network participants. However, a facilitating mechanism has to be set up to make the use of the Internet a success.

Yearly meeting
Participants in the network should meet once a year for at least two days under the auspices of UNESCO to agree on updates to ICF-2000 and to set a working agenda for the next year (see below for a 3-year schedule).

CONDITIONS FOR SUCCESS

Communication activities
A communication plan has to be produced to promote ICF-2000 and the underlying curricula in journals and at key conferences to the target group. Funds have to be allocated to facilitate this promotion. A website, containing ICF-2000 and related materials, has to be set up as soon as possible.

Reflection activities
Also reflection activities have to be organized for the reviewing of ICF-2000 and its implementation. The following 3-year schedule of activities is proposed:

1 a meeting sponsored by UNESCO to co-ordinate implementation activities;
2 an invited paper on ICF-2000 at the IFIP World Computer Congress 2000, Educational Conference (ECUIT 2000) in Beijing;
3 a workshop on the implementation of ICF-2000 at the IFIP World Computer Congress 2000, Educational Conference (ECUIT 2000) in Beijing;
4 sessions on ICF-2000 and its implementation at the IFIP World Conference on Computers in Education WCCE2001 in Copenhagen;
5 a Professional Group on ICF-2000 and its implementation at the IFIP World Conference on Computers in Education WCCE2001 in Copenhagen;
6 an IFIP Working Conference on 'Informatics curricula, teaching methods and best practices' in which ICF-2000 is prominently visible. To be organized in August 2002 in Brazil, back to back with the Annual Conference of the Brazilian Computer Society.

Sponsoring of these activities by or through UNESCO.

Core group
A critical success factor is the existence of an active core group of committed people, based in and sponsored by the participants in the institutional network, that will initiate and monitor activities. The core group should be sponsored, i.e. supported in terms of time and facilities.

Addendum to section 13
Addressing the skills shortage in the Information and Communication Technology (ICT) industry in Europe

A joint response from:
- Nokia Telecommunications;
- Philips Semiconductors;
- Thomson CSF;
- IBM Europe;
- Microsoft Europe;
- Siemens AG;
- British Telecommunications Plc,

referred to in this document as the *'ICT Consortium'*, to the European Commission's communication on *'Job opportunities in the Information Society - how to exploit the employment potential.'*

THE ISSUE

The ICT industry in Europe is experiencing a *severe shortage of skilled personnel*. It is conservatively estimated that there were some 500,000 ICT job vacancies at the end of 1998 and that if action is not taken the number could reach 1,600,000 by 2002 - nearly a three-fold increase[1]. This situation, paradoxical as it is given the high level of unemployment in the EU (over 18 millions unemployed) represents a *major threat* not only to the development of the ICT industry in Europe but also to *the competitiveness of the whole European economy*.

THE PILOT PROJECT

With the support of European Commission seven major ICT companies in Europe, IBM Europe, Nokia Telecommunications, Philips Semiconductors, Thomson CSF, Siemens AG, Microsoft Europe, and British Telecommunications Plc, have embarked on a pilot project to explore new ways of addressing the skills shortage.

Objective

The objective of the project is to put in place a *clear framework* for students, education and training institutions and governments, that describes the skills and competencies required by the ICT industry in Europe.

To achieve that objective the project:
- is developing *generic job profiles* relevant to their main activities;
- will communicate these job profiles, as well as other information about the industry via a common *website*, which is under development.

The goal is that these job profiles will:
- attract more students into ICT courses and employment by providing attractive, plain language profiles of the jobs, roles and opportunities in the industry today;
- provide higher education ICT curriculum designers with clear up-to-date and easily accessible information on the skills needed by the industry;
- assist governments in developing policies to foster the growth of ICT skills in Europe.

It is also proposed to hold a Conference in *Helsinki* on *25 November, 1999* with senior representatives of industry, education/training institutions and governments to consider how best to address the skills shortage.

[1] All statistics taken from the EITO, 1999 Report

The generic job profiles
Thirteen generic job profiles have been developed *to-date* in the following areas:

Telecommunications

1 Radio Frequency (RF) Engineering
2 Digital Design
3 Data Communications Engineering
4 Digital Signal Processing Applications Design
5 Communications Network Design

Software & Services

6 Software & Applications Development
7 Software Architecture and Design
8 Multimedia Design
9 IT Business Consultancy
10 Technical Support

Products & Systems

11 Product Design
12 Integration & Test / Implementation & Test Engineering
13 Systems Specialist

The profiles provide a comprehensive description of the:
- types of jobs in the industry;
- tasks and technologies associated with each job;
- skills and competencies required;
- career opportunities available to those who join the industry.

Eventually it is hoped that with the support of other industry partners, the European Commission, member state governments and the education sector, the number of job profiles will be increased to reflect those areas not adequately covered at the moment and that they will be expanded to describe the specific qualifications and training required, and to identify where such qualifications can be obtained.

THE ICT INDUSTRY IN EUROPE - THE DRIVING FORCE OF THE EU ECONOMY

- The ICT industry in Europe is the most dynamic sector of the EU economy already accounting for more than 5% of EU GDP.
- The European market was 392 billion Euros in 1998 and market growth is set to be 8.2% in 1999.
- While the ICT industry alone directly employs 1,988,000 people, the user industry (i.e. all businesses using information and communication technologies) employ some 8,000,000 ICT personnel.
- All economic activity in Europe today is critically dependent upon ICT. The use of ICT is pervasive throughout the whole society.

THE CONSEQUENCES OF THE ICT SKILLS SHORTAGE

The ICT industry is a fast moving global business and the simple reality is that if immediate action is not taken:
- Europe's economic competitiveness will be adversely affected;
- companies will be urged to relocate outside of Europe; indeed companies are already looking outside of Europe for production and R&D sites;
- our ability to foster European creativity and innovation will inevitably reduce and once outside, it is unlikely that ICT work would move back to Europe;

- the shortage of skilled ICT personnel will become a major factor for investment decisions in all businesses;
- the skills shortage is and will continue to cause a high turnover in staff; global experience shows that this in turn has led to a disincentive to train staff, especially among SMEs; this vicious circle needs to be broken.

To sustain the competitiveness of the European ICT industry in this new changing environment new strategies and actions are urgently needed which will address the skills shortage.

NEXT STEP - PUBLIC & PRIVATE PARTNERSHIP

This pilot project is a small but significant step to addressing the skills shortage. It is hoped however that it will encourage greater dialogue, collaboration and action between the key European players and stakeholders.
The ICT Skills Conference in *Helsinki on 25 November, 1999* will provide a platform for all stakeholders to help shape future strategies in this area.

FURTHER INFORMATION

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14 Acknowledgements and additional information

UNESCO REQUEST

The International Federation for Information Processing (IFIP) has been requested by UNESCO to carry out a project called 'Modular training programme'. IFIP's Technical Committee 3 (TC3, dealing with Education) has adopted the project. It is co-ordinated by the Chair of TC3 and executed mainly by members of Working Group 3.2 (on University Education), complemented with input from the other IFIP Technical Committees.

WORKING DOCUMENTS

This document is the final document of a series of so-called working documents and presents the 'IFIP/UNESCO Informatics Curriculum Framework 2000', abbreviated to ICF-2000. Earlier working documents A and B have been in a process of reviewing, evaluation, development and refinement by the comments of many. Contributed to this process have:

- IFIP Technical Committee 3
- IFIP Technical Committee 9
- IFIP Technical Committee 13
- The IFIP WG 3.2/3.6 Working Conference on "Building university electronic educational environments"
- Members of IFIP Working group 3.2 on Higher Education.

ACKNOWLEDGEMENT OF SOURCES

Please consult the section at the beginning of this document.

ACKNOWLEDGEMENT OF PERSONS

The authors wish to thank the following persons (in alphabetical order) for contributing to the work on the IFIP/UNESCO Informatics Curriculum Framework 2000 (ICF-2000):

- Chrisanthi Avgerou (UK), Chair of IFIP Working Group 9.4;
- Jacques Berleur (B), Chair of IFIP Technical Committee 9 (Relationship between computers and society);
- Monique Grandbastien (F), member of IFIP Technical Committee 3 (Education) and of IFIP Working Group 3.2 (Informatics and ICT in higher education);
- Judy Hammond (AU), Chair of IFIP Technical Committee 13 (Human-Computer Interaction);
- Brian Samways (GB), Chair of IFIP Technical Committee 3 (Education);
- Jan Zabrodski (P), member of IFIP Working Group 3.2 (Informatics and ICT in higher education);
- Members of IFIP Technical Committee 3;
- Members of IFIP Working Group 3.2;
- Programme Committee and participants in the IFIP WG 3.2 and 3.6 Working Conference "Building university electronic educational environments" held at the University of California, Irvine, USA, August 1999.

INTERNATIONAL FEDERATION FOR INFORMATION PROCESSING (IFIP)

IFIP is a non-governmental, non-profit umbrella organization for national societies working in the field of information processing. It was established in 1960 under the auspices of UNESCO as an aftermath of the first World Computer Congress held in Paris in 1959. Today, IFIP has several types of Members and maintains friendly connections to specialized agencies of the UN-system and non-governmental organizations. Technical work, which is the heart of IFIP's activity, is managed by a series of Technical Committees. Each of these committees has two major types of activities - Events and Publications.

IFIP TECHNICAL COMMITTEE 3 ON EDUCATION

est. 1963, revised 1992, 1995, 1998

AIMS

- To provide an international forum for educators to discuss research and practice in:
  - teaching informatics;
  - educational uses of communication and information technologies (ICT).
- To establish models for informatics curricula, training programs, and teaching methodologies;
- To consider the relationship of informatics in other curriculum areas;
- To promote the ongoing education of ICT professionals and those in the workforce whose employment involves the use of information and communication technologies;
- To examine the impact of information and communication technologies on the whole educational environment:
  - teaching and learning;
  - administration and management of the educational enterprise;
  - local, national and regional policy-making and collaboration.

IFIP WORKING GROUP 3.2 ON INFORMATICS AND ICT IN HIGHER EDUCATION

est. 1968, revised 1981, 1989, 1998

The Working Group is concerned with the rôles of both informatics and resulting Information and Communication Technologies (ICT) in higher education.

The mission of the Working Group is to provide a forward look on the development and impact of informatics and resulting technologies in higher education from an international viewpoint. It tries to further the professional work of each of its members and to identify problems, experiences and solutions. It does not strive to offer a unique solution to problems, as it is aware that specific circumstances of people and countries must in general be taken into account.

The Working Group aims to develop effective communication among its members who come from many countries. This communication network, which is based on meetings in person at working conferences and workshops, allows members to actively access state of the art results of research and practice, and to develop a collective expertise. On the basis of this collective expertise, prospective ideas about development and impact of informatics and related technologies in higher education are formed. The collective expertise is shared with others in open conferences, seminars, and consultancy and through publications.
The Working Group strives to achieve a proper understanding of the impact of the information technologies on society in order to be able to define the consequent new professional responsibilities of all students.
The curricular work of the working group aims:

- To revise curricula for informatics dealing with changes both from technological development and from theoretical advances;
- To provide guidance on the informatics component needed in the curricula of all disciplines;
- To provide model curricula, adaptable to various cultural needs and educational systems, especially those of developing countries.

15 References

1 Mulder, F., van Weert, T.J. [eds] (1998) *Informatics in higher education: Views on informatics and noninformatics curricula*, Proceedings of the IFIP/WG3.2 Working Conference on 'Informatics (computer science) as a discipline and in other disciplines: what is in common?'. London, Chapman & Hall.

2 Lidtke, D.K., Mulder, M.C. (1998) 'Meeting the needs of industry: a bold new curriculum in information science'. In: Mulder, F., van Weert, T.J. [eds] (1998) *Informatics in higher education: Views on informatics and noninformatics curricula* (see ref. 1).

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5 Tinsley, J.D.T., van Weert, T. J. [eds] (1994) *Informatics for Secondary Education*, A Curriculum for Schools. Paris, UNESCO.

6 Intergovernmental Committee for the Intergovernmental Informatics Programme Bureau (1997) *Introductory training programme on networked computer applications*, IIP Network Educational Programme. Paris, UNESCO.

16 About the authors

Both authors are participating in activities of IFIP's Working Group 3.2 (on University Education), Tom van Weert being the Chair of this working group. They have co-organised the August'97 international Working Conference on 'Informatics (computer science) as a discipline and in other disciplines: what is in common?', referred to in the main text of this document.

Fred Mulder is since December 1998 working at TSM Business School, the management institute of the three Dutch universities of Twente, Groningen and Eindhoven. He is still associated (honorary) as a professor of informatics education with the Dutch Open University, where he has worked from the start of the institute in 1983 and holds the chair on informatics education since 1991. From 1993 till 1996 he was dean of the Faculty of Engineering. He holds degrees in chemical engineering, in applied mathematics and in theoretical chemistry (Ph.D.). After a postdoc research project in Canada, he went to teach informatics and mathematics in higher professional education, prior to his OU career. He has served on various national committees, such as the quality audit committees for informatics programs at universities as well as higher professional institutes and committees for informatics at secondary schools. In 1997/98 he has spent a 4.5-month sabbatical leave at Georgia Institute of Technology (Atlanta, GA, USA) in order to prepare the start of an international informatics curriculum research project. He is representing The Netherlands in the education committee TC3 of IFIP.

Tom J. van Weert is since September 1998 managing director of the Expert Centre for Innovation and Educational Technology of the Hogeschool van Utrecht, University of Professional Education and Applied Science, The Netherlands. Before that time he was director of the School of Informatics (Computer Science) of the Faculty of Mathematics and Informatics of the University of Nijmegen, The Netherlands. He has been teaching management of large software projects to informatics students who developed real software applications in multidisciplinary teams within the realistic and professional organisational setting of a student software house. Previously he worked in teacher education teaching mathematics and informatics, and prior to that as a computer system engineer in an academic environment. His background is in applied mathematics. He has been active within several IFIP Working Groups and is currently Chair of IFIP Working Group 3.2 on higher education. He is one of the editors of the IFIP/UNESCO 1994 informatics curriculum for secondary schools [5] that has been translated in all major world languages.

Appendices

Appendix A
The ACM Computing Classification System - CCS [1998 Version]

Reference:
http://www.acm.org/class/1998/homepage.html

INTRODUCTION

The 1998 Classification System (CCS) is a cumulative revision of the 1991 version of the Classification System. These changes were instituted under the guidance of Neal Coulter, chairman of the Classification Update Committee. Although the 11 first-level nodes remain unchanged, more than 10 third-level nodes have been added. In addition, a few second-level nodes have been renamed. Furthermore, at the fourth, or subject descriptor, level of the tree, more than 225 new terms were added and more than 150 terms were retired. The framework for the current CCS was established in 1982 and was updated in 1983, 1987, and 1991.

The philosophy that guided the Committee in the development of this Classification System is as follows.

1 The heart of the CCS is a tree, the easiest format in which to represent a hierarchical structure in a linear publication format.
2 The classification tree is restricted to three letter-and-number-coded levels in order that the tree be able to accurately reflect the essential structure of the discipline over an extended period.
3 Subject descriptors (an uncoded fourth level of the tree) provide sufficient detail to cope with new developments in the field. Originally, subject descriptors were intended to change frequently; in practice, however, it is difficult to delete obsolete subject descriptors without obliterating the references to works originally classified under them. Thus, subject descriptors are a permanent part of the tree. Those marked by an asterisk have been "retired" from active usage. Users of the Classification System may still search ACM's online and CD-ROM files using the retired descriptors for items classified before the descriptor was retired. Footnotes indicate the years the items were retired.
4 Counts of past usage of CCS index terms assisted the Update Committee in deciding which terms to retire and which sections to consider for expansion. For the 1998 update, the Committee considered changing the overall structure of the CCS to reflect the rapidly evolving discipline of computing, but the constraint of maintaining a historical search capability as mentioned in item 3 severely limited its options in this respect. The Committee decided to retain the overall structure while implementing changes at lower levels of the tree, in order to have a working CCS that is still recognizable when compared to earlier versions. A major redesign of the CCS that would reach into higher node levels is being considered for the future, however.

The tree consists of 11 first-level nodes and one or two levels under each of these. The set of children of all first and second-level nodes begins with a node General and ends with a node Miscellaneous. The first-level nodes have letter designations (A through K). The second and third levels have combination letter-and-numerical designations. A set of (uncoded) subject descriptors is associated with most leaves of the tree (although seldom with the General and Miscellaneous leaves).

In actual classification usage, first-level nodes (like B. Hardware) are never used to classify material. For material at a general level, the General node (in this case B.0) is used instead. The General node at the first or second level can serve two purposes: it is used for papers that include broad treatments of the topic covered by its parent node (the node immediately preceding it in the tree), or it may cover several topics related to some (but not necessarily all) of its sibling nodes. For example, under K.7 The Computing Profession, the node K.7.0 General would be used to classify a general article on the computing profession, but also could be used for an article that dealt specifically with computing Occupations (K.7.1), Organizations (K.7.2) and Testing, Certification, and Licensing (K.7.3).

General Terms are a defined set of 16 words that typically apply to many areas of the field:

- Algorithms
- Design
- Documentation
- Economics
- Experimentation
- Human Factors
- Languages
- Legal Aspects
- Management
- Measurement
- Performance
- Reliability
- Security
- Standardization
- Theory
- Verification.

The General Terms list is somewhat orthogonal relative to the actual tree.

Below we present the ACM-CCS at three levels, thereby omitting all the subject descriptors (that - by the way - offer a lot of further insight in the meaning of the higher levels). Note that:

- nodes in parentheses indicate a cross-reference to related material;
- a ‘*’ indicates that the classification is no longer used as of January 1991, but that the item is still searchable for previously classified documents;
- a ‘**’ indicates that the classification is no longer used as of January 1998, but that the item is still searchable for previously classified documents.

ACM-CCS THREE-LEVEL TREE

A. GENERAL LITERATURE

- *A.0 General*
- *A.1 Introductory And Survey*
- *A.2 Reference (e.g., dictionaries, encyclopedias, glossaries)*
- *A.m Miscellaneous*

B. HARDWARE

- *B.0 General*
- *B.1 Control Structures And Microprogramming (D.3.2)*
  - B.1.0 General
  - B.1.1 Control Design Styles
  - B.1.2 Control Structure Performance Analysis and Design Aids
  - B.1.3 Control Structure Reliability, Testing, and Fault-Tolerance** (B.8)
  - B.1.4 Microprogram Design Aids (D.2.2, D.2.4, D.3.2, D.3.4)
  - B.1.5 Microcode Applications
  - B.1.m Miscellaneous
- *B.2 Arithmetic And Logic Structures*
  - B.2.0 General
  - B.2.1 Design Styles (C.1.1-2)
  - B.2.2 Performance Analysis and Design Aids** (B.8)
  - B.2.3 Reliability, Testing, and Fault-Tolerance** (B.8)
  - B.2.4 High-Speed Arithmetic
  - B.2.m Miscellaneous
- *B.3 Memory Structures*
  - B.3.0 General
  - B.3.1 Semiconductor Memories (B.7.1)
  - B.3.2 Design Styles (D.4.2)
  - B.3.3 Performance Analysis and Design Aids** (B.8, C.4)
  - B.3.4 Reliability, Testing, and Fault-Tolerance** (B.8)
  - B.3.m Miscellaneous
- *B.4 Input/Output And Data Communications*
  - B.4.0 General
  - B.4.1 Data Communications Devices
  - B.4.2 Input/Output Devices
  - B.4.3 Interconnections (Subsystems)
  - B.4.4 Performance Analysis and Design Aids** (B.8)
  - B.4.5 Reliability, Testing, and Fault-Tolerance** (B.8)
  - B.4.m Miscellaneous
- *B.5 Register-Transfer-Level Implementation*
  - B.5.0 General
  - B.5.1 Design
  - B.5.2 Design Aids
  - B.5.3 Reliability and Testing** (B.8)
  - B.5.m Miscellaneous

- *B.6 Logic Design*
  - B.6.0 General
  - B.6.1 Design Styles
  - B.6.2 Reliability and Testing** (B.8)
  - B.6.3 Design Aids
  - B.6.m Miscellaneous
- *B.7 Integrated Circuits*
  - B.7.0 General
  - B.7.1 Types and Design Styles
  - B.7.2 Design Aids
  - B.7.3 Reliability and Testing** (B.8)
  - B.7.m Miscellaneous
- *B.8 Performance And Reliability (C.4)*
  - B.8.0 General
  - B.8.1 Reliability, Testing, and Fault-Tolerance
  - B.8.2 Performance Analysis and Design Aids
  - B.8.m Miscellaneous
- *B.m Miscellaneous*

C. COMPUTER SYSTEMS ORGANIZATION

- *C.0 General*
- *C.1 Processor Architectures*
  - C.1.0 General
  - C.1.1 Single Data Stream Architectures
  - C.1.2 Multiple Data Stream Architectures (Multiprocessors)
  - C.1.3 Other Architecture Styles
  - C.1.4 Parallel Architectures
  - C.1.m Miscellaneous
- *C.2 Computer-Communication Networks*
  - C.2.0 General
  - C.2.1 Network Architecture and Design
  - C.2.2 Network Protocols
  - C.2.3 Network Operations
  - C.2.4 Distributed Systems
  - C.2.5 Local and Wide-Area Networks
  - C.2.6 Internetworking (C.2.2)
  - C.2.m Miscellaneous
- *C.3 Special-Purpose And Application-Based Systems (J.7)*
- *C.4 Performance Of Systems*
- *C.5 Computer System Implementation*
  - C.5.0 General
  - C.5.1 Large and Medium (”Mainframe”) Computers
  - C.5.2 Minicomputers**
  - C.5.3 Microcomputers
  - C.5.4 VLSI Systems
  - C.5.5 Servers
  - C.5.mMiscellaneous
- *C.m Miscellaneous*

D. SOFTWARE

D.0 General

D.1 Programming Techniques (E)
- D.1.0 General
- D.1.1 Applicative (Functional) Programming
- D.1.2 Automatic Programming (I.2.2)
- D.1.3 Concurrent Programming
- D.1.4 Sequential Programming
- D.1.5 Object-oriented Programming
- D.1.6 Logic Programming
- D.1.7 Visual Programming
- D.1.m Miscellaneous

D.2 Software Engineering (K.6.3)
- D.2.0 General (K.5.1)
- D.2.1 Requirements/Specifications (D.3.1)
- D.2.2 Design Tools and Techniques
- D.2.3 Coding Tools and Techniques
- D.2.4 Software/Program Verification (F.3.1)
- D.2.5 Testing and Debugging
- D.2.6 Programming Environments
- D.2.7 Distribution, Maintenance, and Enhancement
- D.2.8 Metrics (D.4.8)
- D.2.9 Management (K.6.3, K.6.4)
- D.2.10 Design** (D.2.2)
- D.2.11 Software Architecture
- D.2.12 Interoperability
- D.2.13 Reusable Software
- D.2.m Miscellaneous

D.3 Programming Languages
- D.3.0 General
- D.3.1 Formal Definitions and Theory (D.2.1, F.3.1-2, F.4.2-3)
- D.3.2 Language Classifications
- D.3.3 Language Constructs and Features (E.2)
- D.3.4 Processors
- D.3.m Miscellaneous

D.4 Operating Systems (C)
- D.4.0 General
- D.4.1 Process Management
- D.4.2 Storage Management
- D.4.3 File Systems Management (E.5)
- D.4.4 Communications Management (C.2)
- D.4.5 Reliability
- D.4.6 Security and Protection (K.6.5)
- D.4.7 Organization and Design
- D.4.8 Performance (C.4, D.2.8, I.6)
- D.4.9 Systems Programs and Utilities
- D.4.m Miscellaneous

D.m Miscellaneous

E. DATA

- *E.0 General*
- *E.1 Data Structures*
- *E.2 Data Storage Representations*
- *E.3 Data Encryption*
- *E.4 Coding And Information Theory (H.1.1)*
- *E.5 Files (D.4.3, F.2.2, H.2)*
- *E.m Miscellaneous*

F. THEORY OF COMPUTATION

- *F.0 General*
- *F.1 Computation By Abstract Devices*
  - F.1.0 General
  - F.1.1 Models of Computation (F.4.1)
  - F.1.2 Modes of Computation
  - F.1.3 Complexity Measures and Classes (F.2)
  - F.1.m Miscellaneous
- *F.2 Analysis Of Algorithms And Problem Complexity (B.6-7, F.1.3)*
  - F.2.0 General
  - F.2.1 Numerical Algorithms and Problems (G.1, G.4, I.1)
  - F.2.2 Nonnumerical Algorithms and Problems (E.2-5, G.2, H.2-3)
  - F.2.3 Tradeoffs between Complexity Measures (F.1.3)
  - F.2.m Miscellaneous
- *F.3 Logics And Meanings Of Programs*
  - F.3.0 General
  - F.3.1 Specifying and Verifying and Reasoning about Programs (D.2.1, D.2.4, D.3.1, E.1)
  - F.3.2 Semantics of Programming Languages (D.3.1)
  - F.3.3 Studies of Program Constructs (D.3.2-3)
  - F.3.m Miscellaneous
- *F.4 Mathematical Logic And Formal Languages*
  - F.4.0 General
  - F.4.1 Mathematical Logic (F.1.1, I.2.2-4)
  - F.4.2 Grammars and Other Rewriting Systems (D.3.1)
  - F.4.3 Formal Languages (D.3.1)
  - F.4.m Miscellaneous
- *F.m Miscellaneous*

G. MATHEMATICS OF COMPUTING

- *G.0 General*
- *G.1 Numerical Analysis*
  - G.1.0 General
  - G.1.1 Interpolation (I.3.5, I.3.7)
  - G.1.2 Approximation
  - G.1.3 Numerical Linear Algebra
  - G.1.4 Quadrature and Numerical Differentiation (F.2.1)
  - G.1.5 Roots of Nonlinear Equations
  - G.1.6 Optimization
  - G.1.7 Ordinary Differential Equations
  - G.1.8 Partial Differential Equations
  - G.1.9 Integral Equations
  - G.1.10 Applications
  - G.1.m Miscellaneous

G.2 Discrete Mathematics
- G.2.0 General
- G.2.1 Combinatorics (F.2.2)
- G.2.2 Graph Theory (F.2.2)
- G.2.3 Applications
- G.2.m Miscellaneous

G.3 Probability And Statistics
G.4 Mathematical Software
G.m Miscellaneous

H. INFORMATION SYSTEMS

H.0 General
H.1 Models And Principles
- H.1.0 General
- H.1.1 Systems and Information Theory (E.4)
- H.1.2 User/Machine Systems
- H.1.m Miscellaneous

H.2 Database Management (E.5)
- H.2.0 General
- H.2.1 Logical Design
- H.2.2 Physical Design
- H.2.3 Languages (D.3.2)
- H.2.4 Systems
- H.2.5 Heterogeneous Databases
- H.2.6 Database Machines
- H.2.7 Database Administration
- H.2.8 Database Applications
- H.2.m Miscellaneous

H.3 Information Storage And Retrieval
- H.3.0 General
- H.3.1 Content Analysis and Indexing
- H.3.2 Information Storage
- H.3.3 Information Search and Retrieval
- H.3.4 Systems and Software
- H.3.5 Online Information Services
- H.3.6 Library Automation
- H.3.7 Digital Libraries
- H.3.m Miscellaneous

H.4 Information Systems Applications
- H.4.0 General
- H.4.1 Office Automation (I.7)
- H.4.2 Types of Systems
- H.4.3 Communications Applications
- H.4.m Miscellaneous

H.5 Information Interfaces And Presentation (e.g., HCI) (I.7)
- H.5.0 General
- H.5.1 Multimedia Information Systems
- H.5.2 User Interfaces (D.2.2, H.1.2, I.3.6)
- H.5.3 Group and Organization Interfaces
- H.5.4 Hypertext/Hypermedia (I.7, J.7)
- H.5.5 Sound and Music Computing (J.5)
- H.5.m Miscellaneous

H.m Miscellaneous

I. COMPUTING METHODOLOGIES

I.0 General

I.1 Symbolic And Algebraic Manipulation
- I.1.0 General
- I.1.1 Expressions and Their Representation (E.1-2)
- I.1.2 Algorithms (F.2.1-2)
- I.1.3 Languages and Systems (D.3.2-3, F.2.2)
- I.1.4 Applications
- I.1.m Miscellaneous

I.2 Artificial Intelligence
- I.2.0 General
- I.2.1 Applications and Expert Systems (H.4, J)
- I.2.2 Automatic Programming (D.1.2, F.3.1, F.4.1)
- I.2.3 Deduction and Theorem Proving (F.4.1)
- I.2.4 Knowledge Representation Formalisms and Methods (F.4.1)
- I.2.5 Programming Languages and Software (D.3.2)
- I.2.6 Learning (K.3.2)
- I.2.7 Natural Language Processing
- I.2.8 Problem Solving, Control Methods, and Search (F.2.2)
- I.2.9 Robotics
- I.2.10 Vision and Scene Understanding (I.4.8, I.5)
- I.2.11 Distributed Artificial Intelligence
- I.2.m Miscellaneous

I.3 Computer Graphics
- I.3.0 General
- I.3.1 Hardware Architecture (B.4.2)
- I.3.2 Graphics Systems (C.2.1, C.2.4, C.3)
- I.3.3 Picture/Image Generation
- I.3.4 Graphics Utilities
- I.3.5 Computational Geometry and Object Modeling
- I.3.6 Methodology and Techniques
- I.3.7 Three-Dimensional Graphics and Realism
- I.3.8 Applications
- I.3.m Miscellaneous

I.4 Image Processing And Computer Vision
- I.4.0 General
- I.4.1 Digitization and Image Capture
- I.4.2 Compression (Coding) (E.4)
- I.4.3 Enhancement
- I.4.4 Restoration
- I.4.5 Reconstruction
- I.4.6 Segmentation
- I.4.7 Feature Measurement
- I.4.8 Scene Analysis
- I.4.9 Applications
- I.4.10 Image Representation
- I.4.m Miscellaneous

I.5 Pattern Recognition
- I.5.0 General
- I.5.1 Models
- I.5.2 Design Methodology
- I.5.3 Clustering
- I.5.4 Applications
- I.5.5 Implementation (C.3)
- I.5.m Miscellaneous

I.6 Simulation And Modeling (G.3)
- I.6.0 General
- I.6.1 Simulation Theory
- I.6.2 Simulation Languages
- I.6.3 Applications
- I.6.4 Model Validation and Analysis
- I.6.5 Model Development
- I.6.6 Simulation Output Analysis
- I.6.7 Simulation Support Systems
- I.6.8 Types of Simulation
- I.6.m Miscellaneous

I.7 Document And Text Processing (H.4-5)
- I.7.0 General
- I.7.1 Document and Text Editing
- I.7.2 Document Preparation
- I.7.3 Index Generation**
- I.7.4 Electronic Publishing (H.5.4, J.7)
- I.7.5 Document Capture (I.4.1)
- I.7.m Miscellaneous

I.m Miscellaneous

J. COMPUTER APPLICATIONS

J.0 General
J.1 Administrative Data Processing
J.2 Physical Sciences And Engineering
J.3 Life And Medical Sciences
J.4 Social And Behavioral Sciences
J.5 Arts And Humanities
J.6 Computer-Aided Engineering
J.7 Computers In Other Systems (C.3)

J.m Miscellaneous

K. COMPUTING MILIEUX

K.0 General
K.1 The Computer Industry
K.2 History Of Computing
K.3 Computers And Education
- K.3.0 General
- K.3.1 Computer Uses in Education
- K.3.2 Computer and Information Science Education
- K.3.m Miscellaneous

K.4 Computers And Society
- K.4.0 General
- K.4.1 Public Policy Issues
- K.4.2 Social Issues
- K.4.3 Organizational Impacts
- K.4.4 Electronic Commerce (J.1)
- K.4.m Miscellaneous

K.5 Legal Aspects Of Computing
- K.5.0 General
- K.5.1 Hardware/Software Protection
- K.5.2 Governmental Issues
- K.5.m Miscellaneous

K.6 Management Of Computing And Information Systems
- K.6.0 General
- K.6.1 Project and People Management
- K.6.2 Installation Management
- K.6.3 Software Management (D.2.9)
- K.6.4 System Management
- K.6.5 Security and Protection (D.4.6, K.4.2)
- K.6.m Miscellaneous

K.7 The Computing Profession
- K.7.0 General
- K.7.1 Occupations
- K.7.2 Organizations
- K.7.3 Testing, Certification, and Licensing
- K.7.4 Professional Ethics (K.4)
- K.7.m Miscellaneous

K.8 Personal Computing
- K.8.0 General
- K.8.1 Application Packages
- K.8.2 Hardware
- K.8.3 Management/Maintenance
- K.8.m Miscellaneous

K.m Miscellaneous

Appendix B
The Unified Classification Scheme for Informatics - UCSI [rel. 1.2]

Reference:
Mulder, F., Hacquebard, A.E.N. (1998) 'Specifying and comparing informatics curricula through UCSI'. In: Mulder, F., van Weert, T.J. [eds] (1998) Informatics in higher education: Views on informatics and noninformatics curricula (see ref. [1]) [No web site available]

INTRODUCTION

UCSI is a classification system primarily aiming at education and training in informatics in a broad sense. Since its conception in 1992 it has been used in various pilot projects in different educational sectors in the Netherlands. UCSI can be considered as a synthesis of a number of well-known systems from ACM, IEEE, AITP and IFIP. It is an attempt to find a fair balance between the more specific approaches of our field as represented by the original source systems (notably of the three 'classical' and originally rather separate views from what in the USA are called 'computer science', 'computer engineering' and 'information systems'). The system has been utilised and presented at a Working Conference organised in 1997 by IFIP Working Group 3.2 on the theme 'Informatics (computer science) as a discipline and in other disciplines: what is in common?'; see reference [1].

UCSI specifies the discipline of informatics in a four-level knowledge domain tree (like the ACM-CCS does for the discipline of computing). The tree has four (numbered) main domains at the highest level:

1 Computer systems
2 Software systems
3 Information systems
4 Context of informatics.

Each main domain is further specified - apart from 'miscellaneous' - by at most five domains, which in turn are specified by not more than four subdomains (numbered at all levels). The subdomains are specified at a fourth level by sets of selected descriptors.

Below we present UCSI-release 1.2 (1997) at three levels, thereby omitting all the selected descriptors (that - by the way - offer a lot of further insight in the meaning of the higher levels). Note that:

- in main domain 3 the descriptor 'information' is to include also 'knowledge', which implies that:
  'information systems' includes 'knowledge (based) systems',
  'information bases' refer to both 'data bases' and 'knowledge bases',
  'information analysis' also refers to 'knowledge elicitation';
- in main domain 4 the descriptor 'informatics' does not only stand for 'information systems', but for all three other main domains; therefore 'Context' also applies to the more technical areas like industrial automation;

the tree does not contain mathematics subjects, not because these would not be important, but from the point of view that they rather belong to the discipline of mathematics (of course there is a lot of interaction and integration between both disciplines in terms of mutual support and applications).

UCSI THREE-LEVEL TREE

1 COMPUTER SYSTEMS

- *1.1 Hardware structures and digital systems*
  - 1.1.1 Digital components
  - 1.1.2 Circuits and structures
  - 1.1.3 Digital systems
  - 1.1.4 Integrated circuits
  - 1.1.9 Miscellaneous
- *1.2 Computer architecture*
  - 1.2.1 Memory systems
  - 1.2.2 Processor architectures
  - 1.2.3 Instruction sets and data representation
  - 1.2.4 Assembly languages
  - 1.2.9 Miscellaneous
- *1.3 Interfacing and peripherals*
  - 1.3.1 Interfacing technology
  - 1.3.2 Input/output systems
  - 1.3.3 Storage systems
  - 1.3.4 Peripheral devices
  - 1.3.9 Miscellaneous
- *1.4 Communication and networks*
  - 1.4.1 Communication technology
  - 1.4.2 Network architectures
  - 1.4.3 Network protocols
  - 1.4.4 Network management
  - 1.4.9 Miscellaneous
- *1.5 Operating systems and system software*
  - 1.5.1 File and device management
  - 1.5.2 Process management
  - 1.5.3 System management
  - 1.5.4 System software
  - 1.5.9 Miscellaneous
- *1.9 Miscellaneous*

2 SOFTWARE SYSTEMS

- *2.1 Programming languages and environments*
  - 2.1.1 Language constructs
  - 2.1.2 Specific languages and environments
  - 2.1.3 Language processors
  - 2.1.4 Language concepts
  - 2.1.9 Miscellaneous
- *2.2 Software architecture*
  - 2.2.1 Data structures
  - 2.2.2 Algorithms
  - 2.2.3 Programming techniques and strategies
  - 2.2.9 Miscellaneous

2.3 Software engineering (SE)
- 2.3.1 Software requirements and specification
- 2.3.2 Software development process
- 2.3.3 Software exploitation
- 2.3.4 SE methods, techniques and tools
- 2.3.9 Miscellaneous

2.4 Artificial intelligence (Al)
- 2.4.1 Al fields
- 2.4.2 AI methods, techniques and tools
- 2.4.3 Al concepts
- 2.4.9 Miscellaneous

2.5 Theory of computing
- 2.5.1 Formal languages and automata
- 2.5.2 Computability and complexity
- 2.5.3 Semantics of programs
- 2.5.4 Information and coding theory
- 2.5.9 Miscellaneous

2.9 Miscellaneous

3 INFORMATION SYSTEMS

3.1 Information bases (IB)
- 3.1.1 Language constructs
- 3.1.2 Specific languages and environments
- 3.1.3 IB management environments
- 3.1.4 Information base concepts
- 3.1.9 Miscellaneous

3.2 Information systems architecture
- 3.2.1 Information models
- 3.2.2 Process models
- 3.2.3 Event models
- 3.2.9 Miscellaneous

3.3 Information systems (IS) engineering
- 3.3.1 Information analysis
- 3.3.2 IS development process
- 3.3.3 IS exploitation
- 3.3.4 IS engineering methods, techniques and tools
- 3.3.9 Miscellaneous

3.4 Interaction and presentation (IP)
- 3.4.1 IP fields
- 3.4.2 IP methods, techniques and tools
- 3.4.3 IP concepts
- 3.4.9 Miscellaneous

3.5 Theory of information systems (IS)
- 3.5.1 Systems theory for IS
- 3.5.2 Communication and linguistics
- 3.5.3 Human information processing
- 3.5.9 Miscellaneous

3.9 Miscellaneous

4 CONTEXT OF INFORMATICS

- *4.1 Management and informatics*
  - 4.1.1 Project management
  - 4.1.2 Systems management
  - 4.1.3 Quality management
  - 4.1.4 Information strategy and planning
  - 4.1.9 Miscellaneous
- *4.2 Domain specific and dedicated systems*
  - 4.2.1 Dedicated computer systems
  - 4.2.2 General purpose software systems
  - 4.2.3 Domain specific information systems
  - 4.2.9 Miscellaneous
- *4.3 Informatics operational environment*
  - 4.3.1 Informatics suppliers
  - 4.3.2 Informatics clients
  - 4.3.3 Informatics profession
  - 4.3.4 Informatics education
  - 4.3.9 Miscellaneous
- *4.4 Informatics in society*
  - 4.4.1 History of informatics
  - 4.4.2 Social and individual issues
  - 4.4.3 Economic, political and legal issues
  - 4.4.4 Cultural and philosophical issues
  - 4.4.9 Miscellaneous
- *4.9 Miscellaneous*

Appendix C
Computing Curricula 1991 - CC91

References:
http://www.acm.org/education/curr91/homepage.html
http://www.computer.org/educate/cc1991
[Report of the ACM/IEEE-CS Joint Curriculum Task Force]

INTRODUCTION

This report contains curricular recommendations for bachelor programs in the discipline of computing, which includes programs with the titles 'computer science', 'computer engineering', 'computer science and engineering', and other similar titles. The recommendations provide a uniform basis for curriculum design across all segments of the educational community-schools and colleges of engineering, arts and sciences, and liberal arts.

The guidelines in the report provide coverage of new and updated subject matter, including a detailed breakdown of individual lecture and laboratory topics. Fundamental areas of concern in curriculum planning are also addressed: program goals, course design and sequencing, integration of laboratory work, the role of programming, and other related educational experiences. Several sample curricula are illustrated for a variety of academic settings.

The organisation of subject matter in this report follows that presented in the 1988 report *Computing as a Discipline* by Peter Denning et al., which identifies nine subject areas of the discipline. Each of these areas contains topics that are essential and appropriate for all undergraduate curricula in computing. Those topics are presented here as a set of *common requirements* for all programs. Undergraduates should also develop an understanding of the historical, social, and ethical context of the discipline and the profession. Therefore, beyond the nine subject areas, these common requirements also contain subject matter under the heading *Social, Ethical, and Professional Issues*.

The common requirements do not appear here as a single group of courses. Rather, they appear as smaller packages of closely related topics known as *knowledge units*. Different institutions will combine these knowledge units into courses in different ways to meet their particular needs and priorities. However, all students should cover all of the common requirements sometime during their undergraduate careers. This provision ensures a *broad* coverage of the discipline. *Depth* of study in the discipline is also important for all undergraduates. A separate section of the report addresses the advanced and supplemental material that programs need to provide. Students should achieve depth through an appropriate selection of advanced courses.

These recommendations also recognize that mastery of the discipline includes not only an understanding of basic subject matter, but also an understanding of the three processes, or 'points of view', that computing professionals employ and students need to appreciate: *theory, abstraction, and design*. Undergraduate programs should include significant study in each of these three processes. The cohesiveness of computing is also captured in a collection of fundamental concepts that occur repeatedly across all nine subject areas and all three processes of the discipline. These *recurring concepts* provide a framework for integrating subject matter into courses and complete programs of

study. While not all of the recurring concepts are unique to computing, they do tend to summarize fundamental values of the discipline, giving students a means for interrelating diverse topics.

NOTE
Both ACM and IEEE-CS are currently in a process of revising 'Computing Curricula 1991', which is scheduled to yield a new report in the year 2001.

THE COMMON REQUIREMENTS

The common requirements form the basis for a curriculum in computing by providing a platform of knowledge that is considered essential for all students who concentrate in the discipline. The common requirements are expressed below as knowledge units rather than complete courses, to allow different programs to package the subject matter in different ways. Such variations will occur because different institutions and types of programs will have different pedagogical priorities, educational goals, and general constraints within which they implement the common requirements.

AL – ALGORITHMS AND DATA STRUCTURES

(approximately 47 lecture hours)

AL1 Basic Data Structures
AL2 Abstract Data Types
AL3 Recursive Algorithms
AL4 Complexity Analysis
AL5 Complexity Classes
AL6 Sorting and Searching
AL7 Computability and Undecidability
AL8 Problem-Solving Strategies
AL9 Parallel and Distributed Algorithms

AR – ARCHITECTURE

(approximately 59 lecture hours)

AR1 Digital Logic
AR2 Digital Systems
AR3 Machine Level Representation of Data
AR4 Assembly Level Machine Organization
AR5 Memory System Organization and Architecture
AR6 Interfacing and Communication
AR7 Alternative Architectures

AI – ARTIFICIAL INTELLIGENCE AND ROBOTICS

(approximately nine lecture hours)

AI1 History and Applications of Artificial Intelligence
AI2 Problems, State Spaces, and Search Strategies

DB – DATABASE AND INFORMATION RETRIEVAL

(approximately nine lecture hours)

DB1 Overview, Models, and Applications of Database Systems
DB2 The Relational Data Model

HU – HUMAN-COMPUTER COMMUNICATION

(approximately eight lecture hours)

HU1 User Interfaces
HU2 Computer Graphics

NU – NUMERICAL AND SYMBOLIC COMPUTATION

(approximately seven lecture hours)
NU1 Number Representation, Errors, and Portability
NU2 Iterative Approximation Methods

OS – OPERATING SYSTEMS

(approximately 31 lecture hours)
OS1 History, Evolution, and Philosophy
OS2 Tasking and Processes
OS3 Process Coordination and Synchronization
OS4 Scheduling and Dispatch
OS5 Physical and Virtual Memory Organizations
OS6 Device Management
OS7 File Systems and Naming
OS8 Security and Protection
OS9 Communications and Networking
OS10 Distributed and Real-time Systems

PL – PROGRAMMING LANGUAGES

(approximately 46 lecture hours)
PL1 History and Overview of Programming Languages
PL2 Virtual Machines
PL3 Representation of Data Types
PL4 Sequence Control
PL5 Data Control, Sharing, and Type Checking
PL6 Run-time Storage Management
PL7 Finite State Automata and Regular Expressions
PL8 Context-Free Grammars and Pushdown Automata
PL9 Language Translation Systems
PL10 Programming Language Semantics
PL11 Programming Paradigms
PL12 Distributed and Parallel Programming Constructs

SE – SOFTWARE METHODOLOGY AND ENGINEERING

(approximately 44 lecture hours)
SE1 Fundamental Problem-solving Concepts
SE2 The Software Development Process
SE3 Software Requirements and Specifications
SE4 Software Design and Implementation
SE5 Verification and Validation

SP – SOCIAL, ETHICAL, AND PROFESSIONAL ISSUES

(approximately 11 lecture hours)
SP1 Historical and Social Context of Computing
SP2 Responsibilities of the Computing Professional
SP3 Risks and Liabilities
SP4 Intellectual Property

THE ADVANCED AND SUPPLEMENTAL CURRICULUM

A complete curriculum will include not only the common requirements but also certain additional material. This advanced and supplemental material gives each individual student an opportunity to study the subject areas of the discipline in depth. The curriculum should provide depth of study in several of the nine subject areas beyond that provided by the common requirements. Students normally achieve that depth by completing several additional courses in this part of the curriculum. The number of such courses will vary in accordance with institutional norms.

SU – THE ADVANCED AND SUPPLEMENTAL CURRICULUM	
SU1	Advanced Operating Systems
SU2	Advanced Software Engineering
SU3	Analysis of Algorithms
SU4	Artificial Intelligence
SU5	Combinatorial and Graph Algorithms
SU6	Computational Complexity
SU7	Computer Communication Networks
SU8	Computer Graphics
SU9	Computer-Human Interface
SU10	Computer Security
SU11	Database and Information Retrieval
SU12	Digital Design Automation
SU13	Fault-Tolerant Computing
SU14	Information Theory
SU15	Modeling and Simulation
SU16	Numerical Computation
SU17	Parallel and Distributed Computing
SU18	Performance Prediction and Analysis
SU19	Principles of Computer Architecture
SU20	Principles of Programming Languages
SU21	Programming Language Translation
SU22	Real-Time Systems
SU23	Robotics and Machine Intelligence
SU24	Semantics and Verification
SU25	Societal Impact of Computing
SU26	Symbolic Computation
SU27	Theory of Computation
SU28	VLSI System Design

FURTHER DETAILS

We would like to refer to the report for much more comprehensive descriptions of both the common requirements and the advanced and supplemental subjects.

Appendix D
Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems - IS97

References:
http://www.acm.org/education/curricula.html#IS97
http://aisnet.org/reso.shtml
[Report of an ACM/AIS/AITP Joint Curriculum Task Force]

INTRODUCTION

This report was developed by ACM, AIS (Association for Information Systems), and AITP (Association for Information Technology Professionals - formerly DPMA). IS'97 is a model curriculum for undergraduate degree programs in information systems.
Information systems, as an academic field, encompasses two broad areas:

- acquisition, deployment, and management of information technology resources and services (the information systems function);
- development and evolution of technology infrastructures and systems for use in organisation processes (system development).

The model curriculum provides guidelines, a set of courses, source materials, curriculum design objectives, and knowledge elements. It provides advice to a number of intended users of the report who have a stake in the achievement of quality IS degree programs.

The IS'97 curriculum is organised at the highest level as a set of 5 curriculum presentation areas. Each of these areas has one or more courses (in total there are 10 courses). Each course is built from IS learning units. The 127 learning units are derived from the IS body of knowledge which includes more than 1000 elements or topics.

For this appendix it suffices to include only the 10 course descriptions from the report. We refer to the report itself for an extensive presentation of all topics treated (through the IS body of knowledge) as well as for other relevant information.

INFORMATION SYSTEMS COURSE DESCRIPTIONS

The prerequisite software tool kit course plus the ten IS courses are described by a title, scope statement, and topic list. The ten courses represent the IS'97 suggestions for packaging the 139 learning units into courses. There may be factors contingent upon local conditions to cause a faculty to package the learning units in other ways.

IS'97.P0 – KNOWLEDGE WORK SOFTWARE TOOL KIT

SCOPE

IS'97 assumes as a prerequisite elementary exposure to a suite of software tools useful for knowledge workers (spreadsheets, databases, presentation graphics, database retrieval, statistics, word processing, and Internet and electronic mail). Although identified as a course, this material can be delivered as self study modules, as modules associated with other courses using the software, or as a full course.

TOPICS

A Word processing
B E-mail
C Internet tools
D Spreadsheets
E Databases
F Presentation graphics
G External database retrieval
H Introduction to statistical software

IS'97.1 – FUNDAMENTALS OF INFORMATION SYSTEMS

(Prerequisite: IS'97.P0)

SCOPE

This course provides an introduction to systems and development concepts, information technology, and application software. It explains how information is used in organisations and how IT enables improvement in quality, timeliness, and competitive advantage.

TOPICS

A Systems concepts
B System components and relationships
C Cost/value and quality of information
D Competitive advantage and information
E Specification, design and re-engineering of information systems
F Application versus system software
G Package software solutions
H Procedural versus non-procedural programming languages
I Object oriented design
J Database features, functions, and architecture
K Networks and telecommunication systems and applications
L Characteristics of IS professionals and IS career paths

IS'97.2 – PERSONAL PRODUCTIVITY WITH IS TECHNOLOGY

(Prerequisite: IS'97.P0)

SCOPE

This course enables students to improve their skills as knowledge workers through effective and efficient use of packaged software. It covers both individual and group work. The emphasis is on productivity concepts and how to achieve them through functions and features in computer

software. Design and development of solutions focus on small systems.

TOPICS

A End user systems versus organisation systems
B Analysis of knowledge work and its requirements
C Knowledge work productivity concepts
D Software functionality to support personal and group productivity
E Organisation and management of software and data
F Accessing organisation data, accessing external data
G Selecting a computer solution
H Developing a macro program by doing
I Designing and implementing a user interface
J Developing a solution using database software
K Refining and extending individual and group information management activities

IS'97.3 – INFORMATION SYSTEMS THEORY AND PRACTICE

(Prerequisite: IS'97.2)

SCOPE

This course provides an understanding of organisational systems, planning, and decision process, and how information is used for decision support in organisations. It covers quality and decision theory, information theory, and practice essential for providing viable information to the organisation. It outlines the concepts of IS for competitive advantage, data as a resource, IS and IT planning and implementation, TQM and reengineering, project management and development of systems, and end-user computing.

TOPICS

A Information systems and organizational systems
B Quality, TQM and reengineering
C Level of systems: strategic, tactical and operational
D System components and relationships
E Information system strategies
F Roles of information and information technology
G Roles of people using, developing and managing systems
H IS planning
I Human-computer interface
J Network and telecommunications systems management
K Electronic commerce
L Implementation and evaluation of system performance
M Societal and ethical issues related to information systems design and use

IS'97.4 – INFORMATION TECHNOLOGY HARDWARE AND SOFTWARE

(Prerequisite: IS'97.2)

SCOPE

This course provides the hardware/software technology background to enable systems development personnel to understand tradeoffs in computer architecture for effective use in a business environment. System architecture for single user, central, and networked computing systems; single and multiuser operating systems.

TOPICS

A Hardware: CPU architecture, memory, registers, addressing modes, busses, instruction sets, multiprocessors versus single processors
B Peripheral devices: hard disks, CDs, video display monitors, device controllers, input/output
C Operating systems functions and types

D Operating system modules: processes, process management, memory and file system management
E Examples of hardware architectures
F Examples of operating systems
G Basic network components, switches, multiplexers and media
H Installation and configuration of multiuser operating systems

IS'97.5 – PROGRAMMING, DATA, FILE AND OBJECT STRUCTURES

(Prerequisite: IS'97.2)

SCOPE

This course provides an understanding of algorithm development, programming, computer concepts and the design and application of data and file structures. It includes an understanding of the logical and physical structures of both programs and data.

TOPICS

A Data structures and representation: characters, records, files, multimedia
B Precision of data
C Information representation, organization and storage
D Algorithm development
E Object representation compared to conventional data flow notation
F Programming control structures
G Program correct-ness, verification, and validation
H File structures and representation

IS'97.6 – NETWORKS AND TELECOMMUNICATION

(Prerequisites: IS'97.3, IS'97.4)

SCOPE

This course provides an in-depth knowledge of data communications and networking requirements including networking and telecommunications technologies, hardware, and software. Emphasis is upon the analysis and design of networking applications in organisations. Management of telecommunications networks, cost-benefit analysis, and evaluation of connectivity options are also covered. Students learn to evaluate, select, and implement different communication options within an organisation.

TOPICS

A Telecommunication devices, media, systems
B Network hardware and software
C Network configuration
D Network applications
E Coding of data
F Cost/benefit analysis
G Distributed versus centralized systems
H Architectures, topologies and protocols
I Installation and operation of bridges, routers and gateways
J Network performance analysis
K Privacy, security, reliability
L Installation and configuration of LAN and WAN networks
M Monitoring of networks
N Management of telecommunications, and communications standards
O Intranet and internet

IS'97.7 – ANALYSIS AND LOGICAL DESIGN

(Prerequisite: IS'97.3)

SCOPE

This course provides an understanding of the system development and modification process. It enables students to evaluate and choose a system development methodology. It emphasizes the factors for effective communication and integration with users and user systems. It encourages interpersonal skill development with clients, users, team members, and others associated with development, operation and maintenance of the system. Object oriented analysis and design. Use of data modeling tools. Development and adherence to life cycle standards.

TOPICS

A Life cycle phases: requirements determination, logical design, physical design, test planning, implementation planning, and performance evaluation
B Communication, interpersonal skills, interviewing, presentation skills
C Group dynamics
E Risk and feasibility analysis
F Group-based approaches: project management, joint application development (JAD), structured walkthroughs
G Object oriented design
H Software production and reviews
I Prototyping
J Database design
K Software quality metrics
L Application categories
M Software package evaluation and acquisition
N Professional code of ethics

IS'97.8 – PHYSICAL DESIGN AND IMPLEMENTATION WITH DBMS

(Prerequisite: IS'97.7)

SCOPE

This course covers information systems design and implementation within a database management system environment. Students will demonstrate their mastery of the design process acquired in earlier courses by designing and constructing a physical system using database software to implement the logical design.

TOPICS

A Data models and modeling tools/techniques
B Structured and object design approaches
C Models for databases: relational, hierarchical, networked and object oriented designs
D CASE tools
E Data dictionaries, repositories, warehouses
F Implementation: Windows/GUI coding and/or implementa-tion, code/application Generation
G Client-server planning, testing, and installation
H System conversion, end user training/integration and post implementation review.

IS'97.9 – PHYSICAL DESIGN AND IMPLEMENTATION WITH A PROGRAMMING ENVIRONMENT

(Prerequisites: IS'97.5, IS'97.7, and IS'97.8)

SCOPE

This course covers physical design, programming, testing and implementation of the system. Implementations of object-oriented, client-server designs using a programming environment.

TOPICS

A Selection of client-server programming language environment
B Software construction: structured, event driven and object oriented application design
C Testing
D Software quality assurance
E System implementation
F User training
G System delivery
H Post implementation review
I Configuration management
J Maintenance
K Reverse engineering and re-engineering
L Both full client and thin-browser active server based approaches are considered

IS'97.10 – PROJECT MANAGEMENT AND PRACTICE

(Prerequisite: IS'97.7; Corequisites: IS'97.8, IS'97.9)

SCOPE

This course covers the factors necessary for successful management of system development or enhancement projects. Both technical and behavioral aspects of project management are discussed. The focus is on management of development for enterprise-level systems.

TOPICS

A Managing the system life cycle: requirements determination, logical design, physical design, testing, implementation
B System and database integration issues
C Network and client-server management
D Metrics for project management and system performance evaluation
E Managing expectations: superiors, users, team members and others related to the project
F Determining skill requirements and staffing the project
G Cost-effectiveness analysis
H Reporting and presentation techniques
I Effective management of both behavioral and technical aspects of the project
J Change management

Appendix E
An Information Systems-Centric Curriculum ’99 - ISCC99

References:
[Draft report, January 1999]
Mulder, M.C., Lidtke, D.K. [co-chairs Collaborative Academe/Industry Task Force] ‘ISCC’99: An Information Systems-Centric Curriculum ’99. Program Guidelines for Educating the Next Generation of Information Systems Specialists, in Collaboration with Industry’
[Paper conference proceedings, 1998]
Lidtke, D.K., Mulder, M.C. (1998) ‘Meeting the needs of industry: a bold new curriculum in information science’. In: Mulder, F., van Weert, T.J. [eds] (1998) Informatics in higher education: Views on informatics and noninformatics curricula (see ref. 1)
[No web site available]

Draft report (January 1999), endorsement sought by ACM, AIS and IEEE-CS
(supported by the National Science Foundation grants DUE/CIS-9352944, DUE-9455450 and DUE-9796243).

INTRODUCTION

The draft report mentioned above recommends a new curriculum, ISCC’99, to prepare information specialists for the development of large information systems. The main *drivers* of ISCC’99, being an NSF project from 1995 to 1998, are:

- a national need for a strong information systems-centric focus in existing and new academic programs;
- a significant and rapidly growing demand for information systems specialists more closely meeting the needs of the workplace;
- a willingness of industry to be a collaborative partner in achieving these goals.

Important *characteristics of ISCC’99* include:

1 It was developed by a collaborative team equally representing industry and faculty.
2 The requirements for the curriculum were developed by the industry members as a ‘profile of the graduate’ that specified the technical and personal attributes needed to function effectively as an information specialist.
3 Pedagogical aspects such as teaming, just-in-time learning, and a coach/mentor role for the instructor, were incorporated into the curriculum.
4 The curriculum uses an ‘inverted’ model, in which students first experience the context of information systems and applications, and later master details.
5 An ‘information systems-centric’ approach was taken, where the primary focus is the organisation of an information system using information as an enterprise asset.
6 Interpersonal skills, systemic thinking and problem solving techniques were explicitly integrated into the technical components of the curriculum.
7 Enterprise collaboration is required in the delivery and maintenance of the curriculum by providing meaningful project activities, site experiences, case studies, and assistance in updating the curriculum.
8 The curriculum is designed around practical experiences that result in the incremental development of portfolios that demonstrate students’ preparation to function effectively as information systems professionals.

BRIEF COURSE OUTLINES IN MAIN TOPICS

Below we specify the twelve courses of ISCC'99 in terms of the main topics.
We would like to refer to the draft report for comprehensive course outlines that contain, for example:

- lower level topical content;
- expected proficiency levels;
- learning activities;
- industry defined attributes;
- learning/teaching pedagogies.

Most course descriptions also contain references to learning materials.

ISCC-11 – INFORMATION SYSTEMS IN ENTERPRISES

1.0 Enterprise information systems (IS)
Characteristics and case studies
2.0 Information resources in organisations
3.0 Enterprise information system architecture
4.0 Current enabling tools
5.0 Information project cycles

ISCC-21 – INFORMATION SYSTEMS ARCHITECTURE I

1.0 Introduction to information system design
2.0 Introduction to communication and networks
3.0 Introduction to distributed information systems
4.0 Hardware elements of an information system
5.0 External interfaces

ISCC-22 – COMPUTER ETHICS I

1.0 Computer ethics
1.1 Methods of ethical reasoning
1.2 Codes of ethics
1.3 Property rights of software
1.4 Privacy
1.5 Computer crime
1.6 Careers in computing
1.7 Social impacts of computing

ISCC-31 – INFORMATION SYSTEMS ARCHITECTURE II

1.0 Introduction to information abstraction
2.0 Basic information elements
3.0 Comprehensive project

ISCC-32 – COMPUTER ETHICS II

1.0 Why study ethics?
2.0 Professional ethics
3.0 Property rights for software
4.0 Responsibility and liability
5.0 Careers in computing
6.0 Social impacts of computing

ISCC-41 – INFORMATION DATABASES AND TRANSACTION PROCESSING

1.0 Information modeling (external view)
2.0 Internal information structures
3.0 Building a database
4.0 Query processing and optimisation
5.0 Database operations
6.0 Advanced topics

ISCC-42 – TELECOMMUNICATIONS AND NETWORKING

1.0 Data communications and open systems standards
2.0 Data transmission
3.0 Data link protocols
4.0 Local area networks (LANs)
5.0 High speed and bridged LANs
6.0 Wide area networks
7.0 Inter and intra networking
8.0 Open system protocols
9.0 Systems view
10.0 Network management
11.0 Data flow simulation
12.0 Client-server systems

ISCC-43 – HUMAN COMPUTER INTERACTION ISSUES AND METHODS

1.0 Overview of theoretical framework for topics in Human-Computer Interaction (HCI)
2.0 Design and development of systems
3.0 Computer system and interface architecture
4.0 Usability tests and evaluation of HCI
5.0 Human information processing
6.0 Language, communication and interaction
7.0 Adaptation of human systems and technical systems to work as a whole
8.0 Application areas (choose some examples for an in-depth study)
9.0 HCI versus security
10.0 Ergonomics

ISCC-44 – DYNAMICS OF CHANGE

1.0 Introduction to change
2.0 Understanding and coping with change
3.0 Attributes of a change agent
4.0 Learning from failure

ISCC-51 – DISTRIBUTED SYSTEMS

1.0 Distributed systems organisational issues
2.0 Distributed systems and the user's needs
3.0 Distributed systems design issues
4.0 Systems simulation

ISCC-61 – COMPREHENSIVE ENTERPRISE INFORMATION SYSTEMS ENGINEERING

1.0 Introduction to information systems engineering, a change agent
2.0 Information and data gathering for design
3.0 Developing the specification for an information systems system architecture
4.0 Information systems engineering
5.0 Information system methodologies and tools
6.0 Information system feasibility and budgeting
7.0 External information system procurement (build or buy)
8.0 Information system implementation
9.0 A comprehensive case study

ISCC-71 – COMPREHENSIVE COLLABORATIVE PROJECT

SUGGESTED ELECTIVES

ISCC'99 suggests the following elective subjects.

ISCC-EL/T – TECHNICAL COURSES

1.0 Data warehousing and data mining
2.0 Automated decision making: expert systems and neural networks
3.0 Virtual reality in systems
4.0 Artificial intelligence
5.0 Virtuality
6.0 Decision science

ISCC-EL/O – ORGANISATION BEHAVIOURS AND MANAGEMENT

1.0 Micro-economics
2.0 Functional areas in organisations:
- accounting
- finance
- operations management
- marketing
- human resource management

3.0 Project management
4.0 Economics

Appendix F
Curricula for Human-Computer Interaction - HCI92 [1992]

Reference:
http://www.acm.org/sigchi/cdg/
[Report by ACM-SIGCHI]

INTRODUCTION

The ACM Special Interest Group in Computer-Human Interaction (SIGCHI) created a Curriculum Development Group in August, 1988. The task of the committee was to produce a set of recommendations for education in human-computer interaction. In this appendix we refer to the 1992 report from that committee. The committee included members primarily from universities, but also members with experience in industrial organisations. Overall, the report is intended to be a resource for anyone wishing to put together either a single course or a program in human-computer interaction. The goal has been to avoid being prescriptive and to offer a structure which is flexible enough that individuals in differing environments can adapt, modify, and supplement the basic report and its recommendations in ways which are suitable for the environment in which they must work.

COURSE DESCRIPTIONS

Each course description in the report (four in total) contains a sample course catalog description, some comments about the assumed students and prerequisites, a statement of the philosophy and objectives for each course, a topical listing of course content, and many literature references. For this appendix it suffices to only refer to the contents listed in the report, at a global level. We refer to the report itself for a much more comprehensive overview as well as for other relevant information regarding HCI.

CS1 – USER INTERFACE DESIGN AND DEVELOPMENT

1 Introduction to the course (1 hour)
2 Interface quality and evaluation (4 hours)
3 Interactive system and interface design examples (3 hours)
4 Dimensions of interface variability (7 hours)
5 User-centered design and task analysis (7 hours)
6 User interface implementation (10 hours)
7 Evaluation revisited; learning from HCI research; the role of models (2 hours)
8 System and interface design project: presentations and discussion (spread throughout term) (5 hours)
9 Course summary and wrap-up; interfaces of the future (1 hour)
10 Examinations (2 hours)

CS2 – PHENOMENA AND THEORIES OF HUMAN-COMPUTER INTERACTION

1 Introduction to the science of HCI (2 hours)
2 The development process (1 hour)
3 Social organisation and work (4 hours)
4 Methodology (3 hours)
5 Human-machine fit and adaptation (2 hours)
6 The Human Information Processor (9 hours)
7 Application areas in human-computer interaction: a survey of relevant problems and characteristics (1 hour)
8 Languages, Communication and Interaction (5 hours)
9 Ergonomics (2 hours)
10 Design specification techniques (1 hour)
11 Implementation techniques (2 hours)
12 Evaluating the design (3 hours)
13 Case studies of the development and introduction of specific interfaces (2 hours)
14 Special Project and Examinations (5 hours)

PSY1 – PSYCHOLOGY OF HUMAN-COMPUTER INTERACTION

1 Nature of HCI (2 hours)
2 Human Information Processing (7 hours)
3 Computer System and Interface Architecture (10 hours)
4 Use and Context of Computers (9 hours)
5 Development Process (12 hours)
6 Examinations (2 hours)

MIS1 – HUMAN ASPECTS OF INFORMATION SYSTEMS

1 Introduction (5 hours)
2 Analysis (5 hours)
3 Design & Development (22 hours)
4 Implementation/Evaluation (6 hours)
5 Project Presentations and Examinations (4 hours)

Appendix G
The European Computer Driving Licence - ECDL [since 1997]
Reference:
http://www.ecdl.com/

INTRODUCTION

The ECDL is an internationally recognised standard of competence certifying that the holder has the knowledge and skills needed to use the most common computer applications efficiently and productively. In the different countries of Europe study materials have been developed for ECDL in many languages.

The ECDL Foundation works to promote a pan-European certificate of industry-standard computing skills. The ECDL is open to everyone: from large multinational organisations and government bodies to the individual computer user. The European Computer Driving Licence Foundation was established by the Council of European Professional Informatics Societies (CEPIS), to support and co-ordinate the work of the ECDL organisation in each country. Headquartered in Dublin, the ECDLF was established in January 1997 as a not-for-profit company limited by guarantee.

The ECDL has already been adopted by most EU and Scandinavian countries, Hungary and Poland.The Foundation is also gearing-up to introduce the licence in other countries, such as Liechtenstein, Iceland, Lithuania, the Czech Republic, Slovakia, Bulgaria, Romania, Slovenia and Malta. Also an International Computer Driving Licence (ICDL) is in development.

The ECDL is awarded on the successful completion of one test assessing theoretical competence (module 1), and six tests assessing the candidate's competence in using the computer (modules 2 through 7):

- *Module 1 - The Basic Concepts of Information Technology*
  The first basic requirement of competence in computing is to understand the context for computer-based applications in society and the key concepts of computers.
- *Module 2 - Using the Computer and Managing Files*
  It is important to understand the basic housekeeping functions required for the efficient use of the computer.
- *Module 3 - Word processing*
  Using the computer for the creation, editing, formatting, storing and printing of a document. Most documents used today are produced by word processing applications.
- *Module 4 - Spreadsheets*
  This is similar to a manual spreadsheet, with the ability to perform calculations rapidly. It is used in preparing budgets, producing forecasts, business graphics and financial reports.
- *Module 5 - Databases/Filing Systems*
  Assists in the organisation of large volumes of data to allow fast and flexible access to that data.
- *Module 6 - Presentation*
  Graphics have always been an important tool for architects, engineers, illustrators and designers. The use of computer-based presentation and drawing tools has grown in many application areas to support effective communication. These tools are used extensively in business and in teaching.

- *Module 7 - Information Network Services*
  The use of networks has grown from a desire to share resources and to communicate with others. Today, millions of computers are connected together around the world. It is important that ECDL holders can make effective use of the 'Information Super Highway'.

Below we present further outlines of the modules.

ECDL MODULE OUTLINES

MODULE 1 – BASIC CONCEPTS OF INFORMATION TECHNOLOGY

Goals
The individual shall have an understanding of the key concepts of computers and their use in society, and be familiar with how computers affect health and environment. The candidate is required to demonstrate a knowledge of: the basic functionality of a computer and the storage of data, the context for computer-based applications in society, how the basic components of a computer system are assembled and the significance of networking of computers.

Requirements
basic concepts of IT:
- identify the component parts of a computer;
- understand the concept of an operating system;
- understand the function of a computer program;
- understand the concept of storage and memory;
- understand the relationship between the basic units of stored data - bit, byte, record and file;
- inderstand how computer-based systems are developed;
- understand the functionality and use of a graphical user interface;
- understand the concepts of multimedia.

applications and use of computers:
- recognise and understand the importance and growing use of computers and the opportunities offered by their use;
- identify the types of computer-based systems used in business;
- identify the types of computer-based systems used in industry;
- identify the types of computer-based systems used in education;
- identify the types of systems used in the home - for hobbies, household accounts, working at home;
- identify the types of systems encountered in everyday life - for example - in supermarkets, libraries, in the doctor's surgeries, the use of smart cards;
- distinguish between systems software and applications software.

IT and society:
- understand the impact on society of the increased use of computers;
- understand the concept of the 'Information Society';
- express an opinion and reason about the use of computers in circumstances where the computer might be more appropriate than a person, and vice versa;
- be conscious of and apply good practice in the use and care of computer equipment; know what to do if the computer breaks down;
- recognise and avoid potential dangers to health and safety - e.g. ensure that cables are safely secured, power points not overloaded.

security, copyright and the law:

- understand software copyright and the security and legal issues of copying, sharing and lending diskettes (removable discs);
- be aware of privacy issues - responsibility to protect data to which the candidate has access, legitimate uses of such data;
- outline the main points of the Data Protection Act (or relevant Act in your country);
- be aware of security issues - protecting the computer, data and passwords;
- taking back-ups of data;
- understand viruses and anti-virus measures - the candidate must understand how viruses can enter a computer system, what they do, and how to avoid them;
- understand what happens within the computer if there is a power cut.

hardware, systems software and ergonomics:

- know the difference between hardware and software;
- distinguish between various type of computer memory, e.g. RAM and ROM - say why they are used
- understand the purpose of backing store - describe this, and understand storage capacity;
- understand the functions of input and output devices - name some of these and their purpose;
- understand the different types of printer and where they are used in different situations;
- discuss what effects the speed and capacity of the computer; e.g. clock speed, memory, and processor;
- understand the problems, which can occur due to a bad working environment and know what to do about them; for example repetitive strain injury, glare from screens, bad posture.

information network services:

- understand the concepts of data communications and its role in modern information systems;
- e-mail - why is it useful?
- e-mail - what is needed to use it from your own PC/MAC?
- what is needed on your machine to connect to a communications network?
- what is the Internet - how is it useful?
- what is the function of the telephone system in computing? how would you connect to it?
- understand the technology of workgroup computing;
- understand LAN/WAN.

MODULE 2 – USING THE COMPUTER AND MANAGING FILES

Goals

The purpose of this module is to test the candidate's knowledge of the basic housekeeping functions required for the efficient use of the computer. The individual shall show good insights into how an operating system can be used as well as to have the ability to understand and perform normal operations.

Requirements

tasks:

- start the computer;
- create a directory and a sub-directory - understand the directory structure;
- move and copy files;
- delete files from one or more directories;
- create a file, using an editor, and save in a directory; the editor can be a word processing program or a simple editor;
- rename files;

- examine a directory, understand the number of files in that directory, the size of files and the date files were created or updated;
- be able to format a diskette (a removable disc);
- take backup copies of data - copy files onto another diskette or disc (hard disc drive) or onto another directory on the current diskette or disc;
- save files onto a diskette (a removable disc);
- know how to select different printers from an installed list;
- be able to print from an installed printer;
- shut down the computer properly.

MODULE 3 – WORD PROCESSING

Goals
The individual shall have a sound knowledge of how a word processing application can be used. He or she shall be able to understand and accomplish normal everyday operations - editing or creating new documents and be able to use the functions available.

Requirements
word processing basic tasks:
- access a word processing package and load the software;
- open an existing document: enter text, key in text (small amounts), insert text, delete text;
- create a document: enter text, key in text (small amounts), insert text;
- save a document onto a diskette or onto disc;
- use the functions available in a standard word processing system: move text within a document, copy within a document or to another document, replace words with other words;
- change the appearance of text: use italics, embolden text, centre and underline text, change fonts, change line spacing, control justification of text;
- use a spell-check program and make changes where necessary;
- print documents and part of a document;
- create a header and footer;
- change the pagination of a document;
- use pagination;
- use help functions.

word processing advanced tasks:
- indent text;
- merge mailing lists with a document;
- import tables and graphics;
- make a table within a document;
- use and set tabs;
- format documents to a business style in use within an organisation;
- hyphenate;
- use templates;
- use software which integrates word processing with spreadsheet, database or graphics software.

MODULE 4 – SPREADSHEETS

Goals
The individual shall have a sound knowledge of the functions of a spreadsheet application and understand the concept of spreadsheets. He or she shall be able to accomplish common operations - creating a spreadsheet, making calculations and creating diagrams.

Requirements
spreadsheet basic tasks:
- open a spreadsheet file, make changes to it, add rows, calculate new values;
- insert rows and columns - create a new row or column in a specific place;
- create a spreadsheet and enter data: numbers, text, formulae;
- format cells - e.g. size, decimal points, currency, etc;
- adjust column widths and format columns and rows;
- sort the data in the spreadsheet;
- use the basic mathematical and logical functions of a spreadsheet, such as: totalling, averaging;
- print and save a spreadsheet;
- create a header and footer;
- use help functions.

spreadsheet advanced tasks:
- understand and use absolute and relative cell referencing in formulae;
- produce different types of charts and graphs from spreadsheet figures to analyse the data;
- retrieve graphs from diskette or disc;
- print graphs with titles and labels;
- move information between spreadsheets;
- use software which integrates spreadsheet with word processing, database or graphics software.

MODULE 5 – DATABASES/FILING SYSTEMS

Goals
This module tests the candidate's ability to build a small database using a standard database package and create simple queries and reports from an existing database. The individual shall understand the basic concepts of databases.

Requirements
setting up a database:
- design a simple database;
- create the structure of the record;
- enter data into the database;
- edit the data;
- add records;
- delete records;
- define keys;
- save the database to disk;
- search, select and sort data, based on criteria given;
- present selected data in a particular sequence on screen and in reports;
- use help functions.

using an existing database:
- load or log on to an existing database;
- enter data into the database;
- edit the data;
- add records;
- search, select and sort data, based on criteria given;
- present selected data in a particular sequence on screen and in reports;
- modify the database structure;
- use help functions.

MODULE 6 – PRESENTATION

Goals
This module tests the candidate's competence in using presentation tools. The individual shall show a sound knowledge of the functionality of the application. He or she must be able to understand and independently accomplish normal operations. He or she shall be able to demonstrate practical skills in creating a variety of presentations.

Requirements
tasks:
- bullet points to highlight each comment;
- retrieving pictures from a library;
- some simple drawing e.g. boxes, circles, text and lines;
- use of colours, shades and borders;
- use of different fonts and changing of fonts;
- centring, emboldening of text;
- copying and re-sizing drawn objects;
- organisation charts;
- use of slide shows;
- use help functions.

MODULE 7 – INFORMATION NETWORK SERVICES

Goals
This module tests the candidate's understanding of networking concepts, ability to use electronic mail and ability to make use of available information network services.

Requirements
electronic mail:
- send a message;
- make attachments;
- file mail;
- copy mail;
- forward mail.

networks:
depending on the facilities available in the training area and in the test centre, one of the following areas will be assessed:
- connect to the Internet;

- retrieve some information and submit it;

or:

- connect to some public information service;
- retrieve some information and submit it;

or:

- log on to a corporate network;
- connect to an internal service;
- retrieve some information and submit it.