Version 5 – 5th of June 2014

Creative Technology module 5a: Smart Technology

1. Education

Creative Technology

2. Module number and name

Module 5a: Smart Environments

3. Module team

- Edwin Dertien - Sensors
- Peter Breedveld - Control Systems
- Geert Folkertsma - Control Systems
- Gjerrit Meinsma - Control Systems ??
- Cora Salm – Circuits and Electronics
- Erik Faber – Circuits and Electronics
- Mark Bentum - Telecommunications
- Petri van Willigen - Information Specialist
- Joke Oosterhuijs – Educational advisor and specialist
- Paolo Frasca - Systems and Signals
- Erik Faber - Module coordinator

4. Description of the content of the module

This module and its counterpart (Module 5b: New Media) are so called “Tool” modules. In order for the CreaTe student to exert his profession some fundamental knowledge of frequently used tools is necessary. The Smart Technology module focuses on providing such tools on an academic basis. The focus in this module is on physical (mostly electrical or mechanical) systems like telecommunication systems, sensors and controlled systems and the interfacing of such systems to the digital world. In addition signal descriptions in time and frequency domain play an important role, as well as modification, modulation and conversion of signals in time and frequency domain. The treatment of some of the underlying (physical) principles governing such systems will go hand in hand with the treatment on the system level. Practical (lab) skills will play an important role to provide the link between theory and application. In addition, this module contains an individual project which provides the student the opportunity to follow his fascination in technology and deepen his knowledge on a Human-Interface-Device related topic which focuses on the Smart Technology context in close relation with users. The topics of this module are:

		Instructional format				
Topic	**EC**	Lecture	Tutorial	Lab session	Individual feedback	Self study
Project	2	x			x	x
Circuits and Electronics	2.5	x	x	x		
Sensors	3	x		x		x
Telecommunications	2	x	x			x
Control Systems	3	x	x	x		x
Math: systems and signals	2	x	x			x
Tutoring	0.5				x	
Total	15					

Relations between the topics and integration

Roughly speaking, the module contains 3 different parts:

1) Project and Portfolio. The red tread in this module will be the project which enables the student to follow his fascination in Smart Technology and deepen his knowledge. This project will be a literature based project and not a "make and prototype" project. Via the portfolio topic the student can reflect both on the things learned during the project and during the courses and become conscious of the role and usefulness of Smart Technology related tools in the context of his Creative Technology study and his later profession.

2) The four Smart Technology related courses which show strong ties and interconnections towards each other. They serve both the purpose of necessary theory and/or ideas for the project and providing the student with the relevant understanding and mastering of some of the most important concepts, operating principles and theory of present day electronic Smart Technology and Smart Environments. The foundation of Smart Technology is Circuits and Electronics in which the foundation of (passive and active electronic) components and the analysis and operation of basic electric circuits (transients, filtering, amplification, etc.) will be laid down. Sensors is about connecting the physical world to the digital world. Sensors will be treated according to the physical domain in which they operate and will be characterized in practical lab session. The interfacing from analog to digital world also plays a crucial role. Telecommunications provides a basic introduction into the communication aspects of sending and receiving information over short (e.g. in its simplest case via a wire to advanced communication systems like Bluetooth) and long distances (e.g. global communication via satellites). Finally, in the Control Systems course focus will be on modeling (mathematical models, simulation models) of both controlled and uncontrolled systems. Furthermore, the basic principles of simple (e.g. PID) and advanced controllers in both the analog and digital domain will be treated.

3) The Smart Technology related courses are supported by the mathematics course Systems and Signals. It provides the mathematical foundation for all four ST courses. Topics treated include amongst others: goniometric functions, Fourier series and Fourier Transformation, Laplace Transformation and Complex number theory. The math is integrated as much as possible with the ST courses in order to keep a close relationship between mathematical foundation and the application within the ST context.

Project

The individual project is about your (re)search towards your own fascination within the context of Smart Technology. Inspiration can arise from projects in year 1, hobbies, things you think that aren't possible but perhaps they are when you have the right knowledge. The Smart Technology context should be framed into a Human Interface Devices, i.e. the user should also play a central role in the topic of your fascination. You write a research question based on your fascination. This contains the question you want to research and to answer. The project is about going in depth in this research question using literature study. In a literature study you investigate what other scientist have found and achieved regarding your topic. A literature study is useful to know what has been done and investigated so far regarding your question so you don't have to invent the wheel from the beginning. This is an academic skill which will be trained in this module and which will be very useful for your final BSc assignment and future (academic) career. Finally, the student can report his findings both in a written report and via a poster presentation.

Four phases can be distinguished in this project:

Phase 1: Find own fascination and formulate a research question based on this. The research question will be checked and approved by an academic staff member. This phase will take weeks 1 – 4.

Phase 2: find a relevant set of key-words in order to perform the literature survey; perform a literature survey and select 3 relevant scientific papers/articles and discuss and summarise this in a report (part 1 of the report). This will be done in close collaboration with the faculty's information specialist.

Phase 3: relate the findings to the research question and based on this come up with new ideas concerning the product, service, idea, concept, etc. in the research question (part 2 of the report).

Phase 4: All findings will be presented both via a written report and via a poster presentation. The poster presentations will be a joint session with the New Media students.

Guidance throughout the project phase will be offered by one academic staff member who is allocated to the student based on his research question. In addition guidance will be offered by the information specialist in phase 2 of the project.

Project learning goals

At the end of this project the student can:

1. Formulate a research question for a product, idea, service based on his/her fascination in the context of a Human Interface Device, i.e. Smart Technology context in close relation with human beings (users or clients).
2. Perform a scientific literature research based on his knowledge of all steps in the execution of such research.
3. Deliver a small-scale, defined literature research
    a. On the basis of key-words related to the research question, search systematically in the scientific literature
    b. Can select 3 relevant papers or articles from this search
    c. Can summarise those selected papers in a scientific report
    d. Can perform a relevant discussion based on the findings of the literature survey and the research question and draw relevant conclusions (internal consistency)
4. Come to new ideas for products, services, inventions, etc. based on his/her insights from the literature research. These new ideas are related to the own fascination and research question.
5. Present his findings both via a written report and via a poster presentation for his/her fellow students and lecturers.

5. Learning goals of the module and study load of each of the learning goals

The table below shows the topics in the Smart Technology module and their relation with the previous years when Smart Technology was a 15EC track.

Topic	Part of ST track in 2012 – 2013?	EC old	EC in ST module
Intro to Electronics	Yes	4	2.5

Sensors	Yes	4	3
Intro Telecom	Yes	2	2
Networks and Protocols	Yes (will move to module 8)	2	0
Control Systems	Yes	3	3
Systems and Signals	No (was separate course in Y2)	3	2
Creative Exploration of Art Science and Technology	No (was individual project in Y2)	2	2
Tutoring	No (was part of individual course in Y2)	0.5	0.5
Total		20.5	15

The learning goals of this module are:

Nr.	Learning Goal	Total EC load in module
1	based on his/her fascination in the Smart Technology context, can do a scientific literature review in order to obtain deeper scientific insight in his/her topic of investigation so that he/she is able to produce new ideas, services or products	2
2	characterise AC and DC electric networks (using complex numbers)	1.1
3	Characterise resistive, capacitive, magnetic, acoustic and optical sensors	1.3
4	understand mathematical description of (electrical) signals and noise and understand transport and conversion principles and systems in various fields of applications	3.3
5	model 1st and 2nd order electrical systems in the time and frequency domain	1.2
6	model dynamical systems using various methods and representations	2.5
7	design and build analog controllers using blocks and functions from analog electronics	0.7
8	understand advantages and disadvantages of digital and advanced control principles	0.5
9	Perform all necessary steps in laboratory work: building, measuring, analysing electronic circuits; discuss the results and draw conclusions; provide a written representation either in a measurement report or in a log book	2
10	reflect about the importance of smart technology in his/her future profession as a creative technologist	0.5
	Total	15.1

6. Educational formats within the module

The primary formats in which education is provided in this module is via lectures, tutorials, lab sessions, project hours and tutoring. The division of educational formats over the week is given below:

The different educational formats and their distribution over the weeks is given in the table below.

Week	Lectures	Tutorials	Labs	Self study	Tutoring
1	16	2	8	0	2
2	12	4	4	4	2
3	12	4	8	2	2
4	12	6	4	4	2
5	10	4	8	6	2
6	12	10	4	8	2
7	8	6	0	6	2
8	6	2	12	16	2
9	4	4	0	16	2
Total	92	42	48	62	18

Below is the table that shows the amount of hours per course given the EC load of the course (1EC is 28 hours) and the hours that have been scheduled.

Topic	EC	EC in hours	Hours in schedule
Project	2	56	74
Circuits and Electronics	2.5	70	46
Sensors	3	84	36
Telecommunications	2	56	22
Control Systems	3	84	43
Math: systems and signals	2	56	23
Tutoring	0.5	14	18
Total	15	420	262

The total module is worth 15EC which amounts 15 EC · 28 hours/EC = 420 hours of work. 262 hours have been scheduled. The remaining hours (158 hours) has been reserved for testing and mainly self-study.

Week to week schedule

The schedule will differ significantly per week since the basis for the schedule are the learning goals and related topics. Topics per week have been clustered as much as possible in order to offer well integrated and coherent parts of theory and laboratory practices.

The scheduled hours per week per course are given in the table below.

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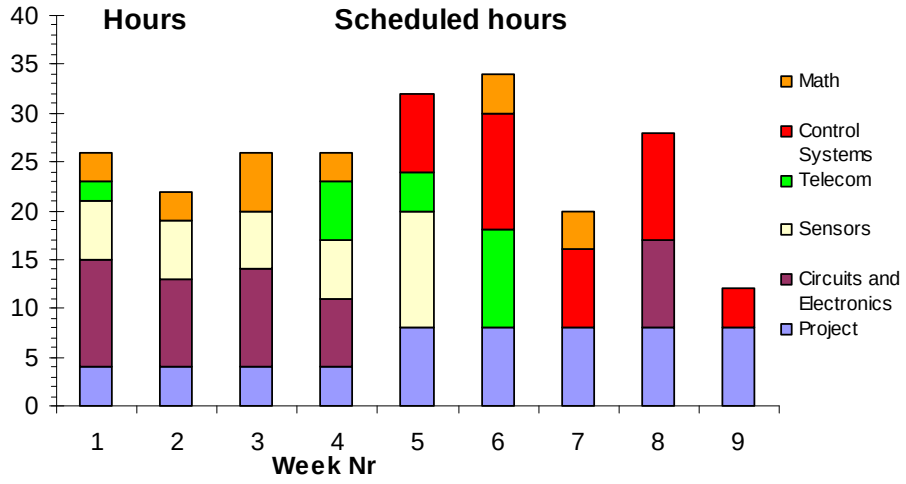

Systems and Signals (Math) and Circuits and Electronics are foundation courses within Smart Tech. and are mainly scheduled in the beginning weeks 1-4. Sensors seamlessly incorporates the knowledge of these courses and connects it to the theory and practice of various sensors in weeks 1-5. Telecommunications will be mainly scheduled in weeks 4 - 6. Control systems will be mainly scheduled in the second part (weeks 5 – 9) of the module. The project has been scheduled for 4 hours of self-study per week in weeks 1-4 and 8 hours per week in weeks 5-8. Weeks 9 and 10 are scheduled for testing and final presentation of the project.

The total schedule of this module is given below.

		36	37	38	39	40	41	42	43	44	45	
		1 Sep 2014	8 Sep 2014	15 Sep 2014	22 Sep 2014	29 Sep 2014	6 Oct 2014	13 Oct 2014	20 Oct 2014	27 Oct 2014	3 Nov 2014	
	1			TESTS	TESTS	TESTS	TESTS	TESTS	TESTS	TESTS		8:45
	2			TESTS	TESTS	TESTS	TESTS	TESTS	TESTS	TESTS		10:30
	3	Kick off College	Project IntSpec L	Sys&Sign4 (2ndO)	Sys&sign3	Project L	Telecom5	Project L	C&E11(id opamp)	Control7 L		10:45
	4	NM en ST	Project IntSpec L	Sys&Sign4 (2ndO)	Sys&sign3	Project L	Telecom5	Project L	C&E11(id opamp)	Control7 L		12:30
Mo	6	Project HC	C&E4 (C&L)	C&E7 (2nd step)	C&E9 (2nd Fil)	Project (self st)	Control1 L	Project (self st)	Control6 L	Control7 T		13:45
	7	Project HC	C&E4 (C&L)	C&E7 (2nd step)	C&E9 (2nd Fil)	Project (self st)	Control1 L	Project (self st)	Control6 L	Control7 T		15:30
	8	C&E1 (Ohm)	C&E5 (1st step)			Project (self st)	Control1 T	Project (self st)				15:45
	9	C&E1 (Ohm)	C&E5 (1st step)			Project (self st)	Control1 T	Project (self st)				17:30
		2 Sep 2014	8 Sep 2014	16 Sep 2014	23 Sep 2014	30 Sep 2014	7 Oct 2014	14 Oct 2014	21 Oct 2014	28 Oct 2014	4 Nov 2014	
	1	Sensors1 L (Res)	Sens2 L (Cap)	Sys&Sign4 T / C&E	Sys&Sign3 T / C&E	Sens5 L (ADDA)				Lab Resit		8:45
	2	Sensors1 L (Res)	Sens2 L (Cap)	Sys&Sign4 T / C&E	Sys&Sign3 T / C&E	Sens5 L (ADDA)				Lab Resit		10:30
	3	C&E2 (superpos)	C&E T		Telecom2	Telecom4	Sys&Sing6 (Lapl)	Sys&Sing7 (Lapl)	C&E/Control T	Lab Resit		10:45
	4	C&E Tut	C&E T		Telecom2	Telecom4	Sys&Sing6 (Lapl)	Sys&Sing7 (Lapl)	C&E/Control T	Lab Resit		12:30
Tue	6	Sens1 lab (6-9)	Sens2 Lab	C&E Lab (2nd O)	C&E / Telecom T	Sens5 Lab	Telecom Lab?	Control 4 L	C&E Lab (Opamp)	Control 8 L		13:45
	7	Sens 1 lab (6-9)	Sens2 Lab	C&E Lab (2nd O)	C&E / Telecom T	Sens5 Lab	Telecom Lab?	Control4 L	C&E Lab (Opamp)	Control 8 L		15:30
	8	Vrijhof lab (6-9)	Sens2 Lab	C&E Lab (2nd O)		Sens5 Lab	Telecom Lab?	Control 4 T	C&E Lab (Opamp)	Control 8 T		15:45
	9	Vrijhof lab (6-9)	Sens2 Lab	C&E Lab (2nd O)		Sens5 Lab	Telecom Lab?	Control4 T	C&E Lab (Opamp)	Control 8 T		17:30
		3 Sep 2014	10 Sep 2014	17 Sep 2014	24 Sep 2014	1 Oct 2014	8 Oct 2014	15 Oct 2014	22 Oct 2014	29 Oct 2014	5 Nov 2014	
	1	Sens1 lab (1-4)	Project guest L		C&E10 (diode,FET)		Control2 L					8:45
	2	Sens1 lab (1-4)	Project guest L		C&E10 (diode,FET)		Control2 L					10:30
	3	Vrijhof lab (1-4)	Sys&sign2 (CN)	Sys&sign5 (LTI)	Telecom3	Telecom T	Control2 T		C&E12 (Non Id Opamp)			10:45
	4	Vrijhof lab (1-4)	Sys&sign2 (CN)	Sys&sign5 (LTI)	Telecom3	Telecom T	Control2 T		C&E12 (Non Id Opamp)			12:30
Wed	6	Tutoring (6-9)	Tutoring (6-9)	Project FormResQ	Project chk ResQ	Tutoring (6-9)	Tutoring (6-9)	Tutoring (6-9)	Tutoring (6-9)	Tutoring (6-9)		13:45
	7	Tutoring (6-9)	Tutoring (6-9)	Project FormResQ	Project chk ResQ	Tutoring (6-9)	Tutoring (6-9)	Tutoring (6-9)	Tutoring (6-9)	Tutoring (6-9)		15:30
	8	Vrijhof lab (6-9)	Project Self (6-9)	Project FormResQ	Project chk ResQ	Project Self (6-9)	Project Self (6-9)	Project Self (6-9)	Project self (6-9)	Project self (6-9)		15:45
	9	Vrijhof lab (6-9)	Project Self (6-9)	Project FormResQ	Project chk ResQ	Project Self (6-9)	Project Self (6-9)	Project Self (6-9)	Project self (6-9)	Project self (6-9)		17:30
		4 Sep 2014	11 Sep 2014	18 Sep 2014	25 Sep 2014	2 Oct 2014	9 Oct 2014	16 Oct 2014	23 Oct 2014	30 Oct 2014	6 Nov 2014	
	1	Sys&Sign1	C&E6 (com imp)	C&E8 (1st Fil)		Sens6 L (opt)	Telecom 6	Control5 L	Control lab (PID)			8:45
	2	Sys&Sign1	C&E6 (com imp)	C&E8 (1st Fil)		Sens6 L (opt)	Telecom 6	Control5 L	Control lab (PID)			10:30
	3	C&E3 (signals)	Sys&Sign2 T / C&E	Sens3 L (Magn)	Sens4 L (Acou)	Multiport&Matrix L	Telecom T	Control5 T	Control lab (PID)			10:45
	4	C&E3 (signals)	Sys&Sign2 T / C&E	Sens3 L (Magn)	Sens4 L (Acou)	Multiport&Matrix L	Telecom T	Control5 T	Control lab (PID)			12:30
Thu	6	Telecom1	Self St. / GOGBOT	Sens3 Lab	Sens4 Lab	Sens6 Lab	Control3 L	Project (self s)	Control lab (PID)	Project (self st)		13:45
	7	Telecom1	Self St. / GOGBOT	Sens3 Lab	Sens4 Lab	Sens6 Lab	Control3 L	Project (self s)	Control lab (PID)	Project (self st)		15:30
	8		Self St. / GOGBOT	Sens3 Lab	Sens4 Lab	Sens6 Lab	Control3 T	Project (self s)	Control lab (PID)	Project (self st)		15:45
	9		Self St. / GOGBOT	Sens3 Lab	Sens4 Lab	Sens6 Lab	Control3 T	Project (self s)	Control lab (PID)	Project (self st)		17:30
		5 Sep 2014	12 Sep 2014	19 Sep 2014	26 Sep 2014	3 Oct 2014	10 Oct 2014	17 Oct 2014	24 Oct 2014	31 Oct 2014	7 Nov 2014	
	1		Self St. / GOGBOT	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review		8:45
	2		Self St. / GOGBOT	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review	Test Peer Review		10:30
	3	Sys&Sign1 T /C&E	Self St. / GOGBOT	Sys&Sign5 T / C&E	C&E / Telecom T	Multiport& Matrix T	Sys&Sign6 T / Cont	Sys&Sign7 T / Cont	Project (self st)	Project (self st)		10:45
	4	Sys&Sign1 T /C&E	Self St. / GOGBOT	Sys&Sign T / C&E	C&E / Telecom T	Multiport& Matrix T	Sys&Sign6 T / Cont	Sys&Sign7 T / Cont	Project (self st)	Project (self st)		12:30
Fri	6	Project guest L	Self St. / GOGBOT	Project guest L	Project LstChk Q	Project (self s)	Project (self s)	Project (self s)	Project (self st)	Project (self st)		13:45
	7	Project guest L	Self St. / GOGBOT	Project guest L	Project LstChk Q	Project (self s)	Project (self s)	Project (self s)	Project (self st)	Project (self st)		15:30
	8		Self St. / GOGBOT			Project (self s)	Project (self s)	Project (self s)	Project (self st)	Project (self st)		15:45
	9		Self St. / GOGBOT			Project (self s)	Project (self s)	Project (self s)	Project (self st)	Project (self st)		17:30

7. Course descriptions of the components

[taken from last year descriptions. Update needed???]

General introduction on the Smart Technology module

Since the start of the information technology about 50 years ago the world we live in shows a higher complexity and functionality. At first all artificial intelligence was isolated to our personal computers or other complex (and often expensive) devices. Nowadays also simple and cheap devices in our daily environments evolve rapidly in the sense that they become more versatile and more intelligent or "smarter". A product or functional space is not anymore invented for a sole purpose but shows multifaceted interaction with users and other (sub)systems. These "smarter" environments and products all have in common that in order to operate properly at such high complexity they:

1. Contain electronic circuitry for signal processing such as: filtering, signal or power conversions, amplification, etc.,
2. sense or measure physical quantities in their environment and have an effect on the environment or user,
3. communicate within subsystems of the device or between devices over short or long distances,
4. contain intelligent software or hardware (in so called embedded systems) in which the sensory information is used for steering towards optimal and desired behavior.

The Smart Technology course aims at supplying the right balance between theory and practice on the technological side of smart products and smart environments. It trains students in the engineering skills and attitude necessary for developing, understanding, testing and prototyping Smart Products. This course consists of four topics or building blocks of a smart product:

The project

The project description is provided in chapter 4.

Circuits and Electronics

electronic components and the functions engineered with them are fundamental in every smart product. This block trains basic understanding of electronic components (resistor, capacitor, inductor, transistor, IC etc) and their applications in electronic networks, filters, amplifiers, converters, etc. Moreover, basics in signal analysis in the time and frequency domain and in the analog and digital domain are treated here.

Sensors

To make products smart or 'aware', they need to get input from users or their environment, typically using sensors. Various sensing domains (locative, environmental, bio) are explained and various sensing principles (resistive, capacitive, magnetic, optical, ultrasonic). All necessary steps in a given sensing system (sensing, conditioning, conversion, interpreting) are explained and necessary tools (periodic/aperiodic signals, ADC design, (instrumentation) amplifiers, conditioning circuits) are deployed, aimed at embedded system design. Finally an insight is given in advanced sensing techniques and operations (fft, kalman filtering, sensor fusion, imaging)

Introduction to Telecommunication

every product needs to communicate. This focus here is on the interaction between technical subsystems (e.g. ,a phone that connects to a satellite for sending and receiving the speech information or text). In most cases, signals

cannot be transmitted straight forward but need a modulation in order to be transmitted over certain media. This requires knowledge on signal analysis and on signal modulation and demodulation techniques. Moreover, understanding of influence of media properties (e.g., coax, glass fibre, air etc.) on signal transport and how to influence them are fundamental in every smart product and are treated here. The second part will focus on the network aspects of communication systems. Medium access control mechanisms, internet protocols and end-to-end protocols and network applications will be treated here.

Control Systems

Most smart products need to do something in our world. Think of products like a 3D printer, balancing scooter (segway) or a quadcopter (drone). They need to deploy actuators and be able to control them, either autonomously or with intervention of the user. Control Systems deals with both aspects of control. Describing and modelling dynamic behaviour and designing and realizing control methods. Classical feedback control (PID, root locus design) is treated in depth. Finally an insight is given in more complex control strategies (Fuzzy, Neural networks, MiMO)

Systems and Signals (Math)

The main goal of this course is to introduce the student to some concepts from mathematics that will be needed in courses such as control systems, telecommunication and other courses in the Smart Technology track. In itself it provides the student with a new tool for analyzing time signals. It also enables the student to understand the dynamical behavior of linear differential equations, which is the basic model in dynamical systems, both for mechanical and electrical networks. After the course the students will have attained a familiarity with the main concepts and a certain fluency with working with these concepts. [This definitely has to be adapted; this is obsolete…]

Tutoring

Creative Technology emphasizes that students should take their own responsibility for setting and reaching the ambitions for their future. Creative Technology students are self-directing learners. They collect their progress in a portfolio. They start in the first year and continue in the second and third year. The portfolio is a proof of long term development as a "Creative Technologist." Tutors assist students in their self-directed learning. Students and tutors use the Creative Technology Tutoring Syllabus ("The road to the final qualifications of a Creative Technology graduate") as a guideline for setting goals and monitoring progress towards reaching those goals. Together with the tutor and their peers students select competencies that fit the ambitions of their future career. Together they look for ways to achieve these ambitions.

Study Studiemateriaal

[To be updated?]

Books

- Neil Storey, "Electronics, a systems approach", 5th edition, Pearson Education, Inc, **2013**. ISBN-13: 9780273773276, ISBN-10: 0273773275. Book for Circuits and Electronics and reference book for the complete Smart Technology track.
- S. Haykin and M. Moher, "Introduction to Analog and Digital Communications". Book for Intro to Telecommunications.
- Job van Amerongen, "Dynamical Systems for Creative Technology", 2nd edition, Enschede, **2011**. Book for Control Systems and reference book for the complete Smart Technology track.

Readers etc.

- Reader: "Circuits and Electronics "

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- Reader: "Sensors"
- Reader(s): “Control Systems”
- Toolkit: "Arduino starter kit". Available as ‘Create ProtoBox’ at the STORES
- Sheets and handouts with assignments

8. Assesment and assesment criteria

The components of this module are:

1. The project
2. The four ST theory supplying courses: circuits and Electronics, Sensors, Intro to Telecommunicatons and Control Systems; and the supporting math course: systems and signals.
3. Tutoring

The project and tutoring are individually graded. The theory supplying courses, however, are assessed via integral tests. The module learning goals form the basis for this. The module learning goals, their respective weight in ECs and the contributions of the courses to the respective learning goals are given below in the table.

Nr.	Learning Goal	Learning goal level (tax. Bloom)	Learning goald finished in week	Total EC load in module	Project	Circuits and Electronics	Sensors	Telecom	Control Systems	Systems and Signals	Portfolio
1	based on his/her fascination in the Smart Technology context, can do a scientific literature review in order to obtain deeper scientific insight in his/her topic of investigation so that he/she is able to produce new ideas, services or products	5	10	2	100% 2EC						
2	characterise AC and DC electric networks (using complex numbers)	4	2	1.1		72% 0.8EC				28% 0.3EC	
3	Charcterise resistive, capacitive, magnetic, acoustic and optical sensors	4	5	1.3			100% 1.3EC				
4	understand mathematical description of (electrical) signals and noise and understand transport and conversion principles and systems in various fields of applications	4	6	3.3		6% 0.2EC	15% 0.5EC	61% 2EC		18% 0.6EC	
5	model 1st and 2nd order electrical systems in the time and frequency domain	4/5	4	1.2		50% 0.6EC				50% 0.6EC	
6	model dynamical systems using various methods and representations	4	7	2.5					76% 1.9EC	24% 0.6EC	
7	design and build analog controllers using blocks and functions from analog electronics	5/6	8	0.7		70% 0.5EC			30% 0.2EC		
8	understand advantages and disadvantages of digital and advanced control principles	2	9	0.5					100% 0.5EC		
9	Perform all necessary steps in laboratory work: building, measuring, analysing electronic circuits; discuss the results and draw conclusions; provide a written representation either in a measruement report or in a log book	6	8	2		20% 0.4EC	60% 1.2EC		20% 0.4EC		
10	reflect about the importance of smart technology in his/her future profession as a creative technologist	6	10	0.5							100% 0.5EC
				15.1		2.50	3.00	2.00	3.00	2.10	

In the column right to the learning goals the learning goal level is indicated according to the taxonomy of Bloom with 1 being the lowest level and 6 the highest level (see Appendix A). The next column shows in which week the specific learning goals is finished being taught.

Learning goals 1 and 10 belong totally to the project and tutoring, respectively. They are finished in week 10.

Learning goal 9 belongs to the lab and practical skills in the module and is finished in week 8.

Learning goals 2-8 belong to the theoretical components of this module and are assessed via written tests per learning goal.

Learning goals 2-9 will be tested via "integral testing". They will be assessed via written tests only not via separate test per course. Instead, test will be about the learning goals and as can be seen in the table above multiple courses can contribute to a learning goal. The module coordinator will coordinate the compilation of all tests. The test scheme will look as the table below.

Week	Test on learning goal	EC load	Cum. EC load	Resit on learning goal
1	-	-	0	-
2	-	-	0	-
3	2	1.1	1.1	-
4	-	-	1.1	-
5	5	1.2	2.3	2
6	3	1.3	3.6	-
7	4	3.3	6.9	5
8	6	2.5	9.4	3
9	7,8	1.2	10.6	4
10	9 (lab)	2	12.6	6
After week 10	1,10	2.5	15.1	7,8

Note: learning goals 2-8 are tested via written tests; a total of 6 written tests are proposed. Learning goal 9 is the lab session and is assessed via lab journals and/or lab reports. Learning goals 1 is the project and is assessed via a written report and poster presentation. Learning goal 10 is the portfolio and is assessed by the tutor both on update of the student's portfolio and on a self reflection essay of the student.

For each written test a resit is scheduled two weeks after the first attempt.

[There is still much work in progress on assessment. At this moment previous tests of the 5 theoretical courses are being screened and categorized in Test matrices in order to make an example on how the old tests could fit in the testing scheme proposed above]

9. Evaluation plan

[Under construction]

Formal evaluation of this module will be done by:

- The CreaTe Evaluation Committee (CREEC). They will organize three times a panel discussion with a group of participating students in this module. Two evaluations will be done during the module and the final one is after the module has finished.

- There will be a formal UT questionnaire at the end of the module.

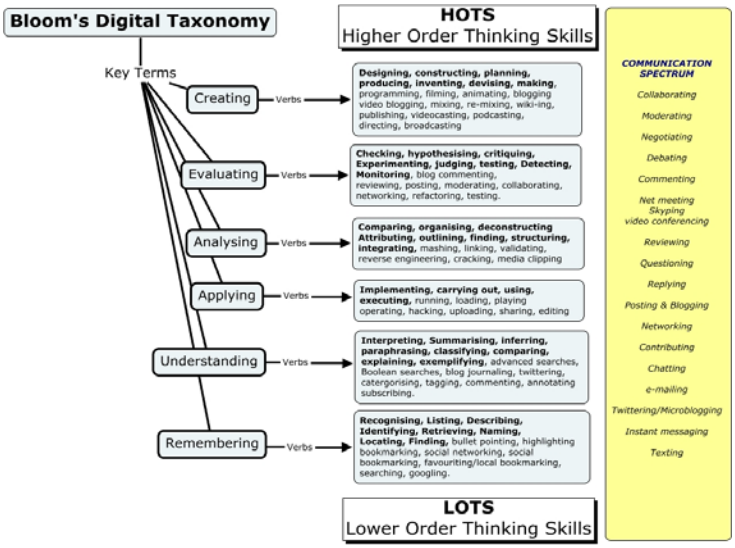
Informal evaluation will be done by the teachers in this module. Half-way the module a written questionnaire will be planned accompanied with individual talks with the students.

Appendix A – Taxonomy of Bloom

A1 Bloom's taxonomy is a way of distinguishing questions within education. It is named for Benjamin Bloom, who chaired the committee of educators that devised the taxonomy, and who also edited the first volume of the standard text, *Taxonomy of Educational Objectives: The Classification of Educational Goals*.[1]

Bloom's taxonomy refers to a classification of the different objectives that educators set for students (learning objectives). It divides educational objectives into three "domains": cognitive, affective, and psychomotor (sometimes loosely described as "knowing/head", "feeling/heart" and "doing/hands" respectively). Within the domains, learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels.[2] A goal of Bloom's taxonomy is to motivate educators to focus on all three domains, creating a more holistic form of education.[1]

Bloom's taxonomy is considered to be a foundational and essential element within the education community.[3] A mythology has grown around the taxonomy, possibly due to many people learning about the taxonomy through second hand information. Bloom himself considered the Handbook "one of the most widely cited yet least read books in American education".[4]



A1.2 Cognitive domain

Categories in the cognitive domain of the revised Bloom's taxonomy (Anderson et al. 2000)

Skills in the **cognitive domain** revolve around knowledge, comprehension, and critical thinking on a particular topic. Traditional education tends to emphasize the skills in this domain, particularly the lower-order objectives.

There are six levels in the taxonomy, moving through the lowest order processes to the highest:

Knowledge

Exhibit memory of learned materials by recalling facts, terms, basic concepts and answers

- Knowledge of specifics - terminology, specific facts
- Knowledge of ways and means of dealing with specifics - conventions, trends and sequences, classifications and categories, criteria, methodology
- Knowledge of the universals and abstractions in a field - principles and generalizations, theories and structures

Questions like: What are the health benefits of eating apples?

Comprehension

Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating the main ideas

- Translation
- Interpretation
- Extrapolation

Questions like: Compare the health benefits of eating apples vs. oranges.

Application

Using acquired knowledge. Solve problems in new situations by applying acquired knowledge, facts, techniques and rules in a different way

Questions like: Which kinds of apples are best for baking a pie, and why?

Analysis

Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations

- Analysis of elements
- Analysis of relationships
- Analysis of organizational principles

Questions like: List four ways of serving foods made with apples and explain which ones have the highest health benefits. Provide references to support your statements.

Synthesis

Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions

- Production of a unique communication
- Production of a plan, or proposed set of operations
- Derivation of a set of abstract relations

Questions like: Convert an "unhealthy" recipe for apple pie to a "healthy" recipe by replacing your choice of ingredients. Explain the health benefits of using the ingredients you chose vs. the original ones.

Evaluation

Present and defend opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria

- Judgments in terms of internal evidence
- Judgments in terms of external criteria

Questions like: Do you feel that serving apple pie for an after school snack for children is healthy?

A1.3 Affective domain

Skills in the **affective domain** describe the way people react emotionally and their ability to feel other living things' pain or joy. Affective objectives typically target the awareness and growth in attitudes, emotion, and feelings.

There are five levels in the affective domain moving through the lowest order processes to the highest:

Receiving

The lowest level; the student passively pays attention. Without this level no learning can occur. Receiving is about the student's memory and recognition as well.

Responding

The student actively participates in the learning process, not only attends to a stimulus; the student also reacts in some way.

Valuing

The student attaches a value to an object, phenomenon, or piece of information. The student associates a value or some values to the knowledge he acquired.

Organizing

The student can put together different values, information, and ideas and accommodate them within his/her own schema; comparing, relating and elaborating on what has been learned.

Characterizing

The student holds a particular value or belief that now exerts influence on his/her behavior so that it becomes a characteristic.

A1.4 Psychomotor domain

Skills in the **psychomotor domain** describe the ability to physically manipulate a tool or instrument like a hand or a hammer. Psychomotor objectives usually focus on change and/or development in behavior and/or skills.

Bloom and his colleagues never created subcategories for skills in the psychomotor domain, but since then other educators have created their own psychomotor taxonomies.[6] Simpson (1972) proposed the following levels:

Perception

The ability to use sensory cues to guide motor activity. This ranges from sensory stimulation, through cue selection, to translation. Examples: Detects non-verbal communication cues. Estimate where a ball will land after it is thrown and then moving to the correct location to catch the ball. Adjusts heat of stove to correct temperature by smell and taste of food. Adjusts the height of the forks on a forklift by comparing where the forks are in relation to the pallet. Key Words: chooses, describes, detects, differentiates, distinguishes, identifies, isolates, relates, selects.

Set

Readiness to act. *It includes mental, physical, and emotional sets. These three sets are dispositions that predetermine a person's response to different situations* (sometimes called mindsets). Examples: Knows and acts upon a sequence of steps in a manufacturing process. Recognize one's abilities and limitations. Shows desire to learn a new process (motivation). NOTE: This subdivision of Psychomotor is closely related with the "Responding to phenomena" subdivision of the Affective domain. Key Words: begins, displays, explains, moves, proceeds, reacts, shows, states, volunteers.

Guided response

The early stages in learning a complex skill that includes imitation and trial and error. Adequacy of performance is achieved by practicing. Examples: Performs a mathematical equation as demonstrated. Follows instructions to build a model. Responds to hand-signals of instructor while learning to operate a forklift. Key Words: copies, traces, follows, react, reproduce, responds

Mechanism

This is the intermediate stage in learning a complex skill. *Learned responses have become habitual and the movements can be performed with some confidence and proficiency*. Examples: Use a personal computer. Repair a leaking tap. Drive a car. Key Words: assembles, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches.

Complex overt response

The skillful performance of motor acts that involve complex movement patterns. Proficiency is indicated by a quick, accurate, and highly coordinated performance, requiring a minimum of energy. This category includes performing without hesitation, and automatic performance. For example, players will often utter sounds of satisfaction or expletives as soon as they hit a tennis ball or throw a football, because they can tell by the feel of the act what the result will produce. Examples: Maneuvers a car into a tight parallel parking spot. Operates a computer quickly and accurately. Displays competence while playing the piano. Key Words: assembles, builds, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches. NOTE: The Key Words are the same as Mechanism, but will have adverbs or adjectives that indicate that the performance is quicker, better, more accurate, etc.

Adaptation

Skills are well developed and the individual can modify movement patterns to fit special requirements. Examples: Responds effectively to unexpected experiences. Modifies instruction to meet the needs of the learners. Perform a task with a machine that it was not originally intended to do (machine is not damaged and there is no danger in performing the new task). Key Words: adapts, alters, changes, rearranges, reorganizes, revises, varies.

Origination

Creating new movement patterns to fit a particular situation or specific problem. Learning outcomes emphasize creativity based upon highly developed skills. Examples: Constructs a new theory. Develops a new and comprehensive training programming. Creates a new gymnastic routine. Key Words: arranges, builds, combines, composes, constructs, creates, designs, initiate, makes, originates.

A1.5 Definition of knowledge

In the appendix to Handbook I, there is a definition of knowledge which serves as the apex for an alternative, summary classification of the educational goals. This is significant as the taxonomy has been called upon significantly in other fields such as knowledge management, potentially out of context.

Knowledge, as defined here, involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting.

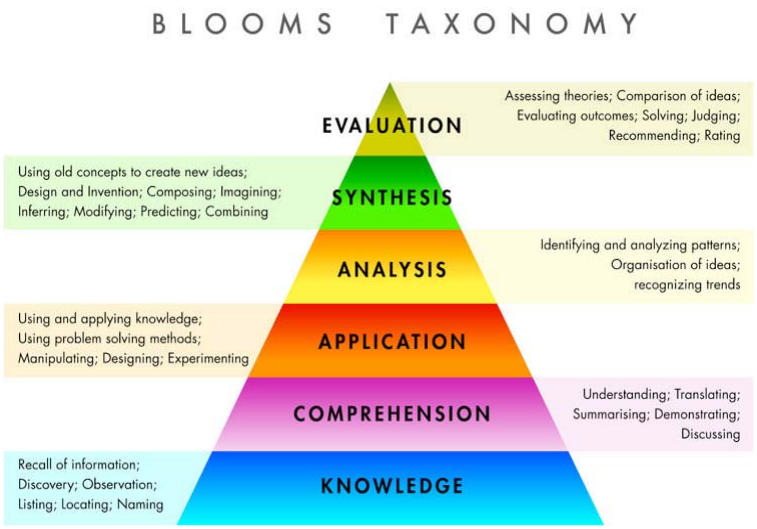
__ [9]

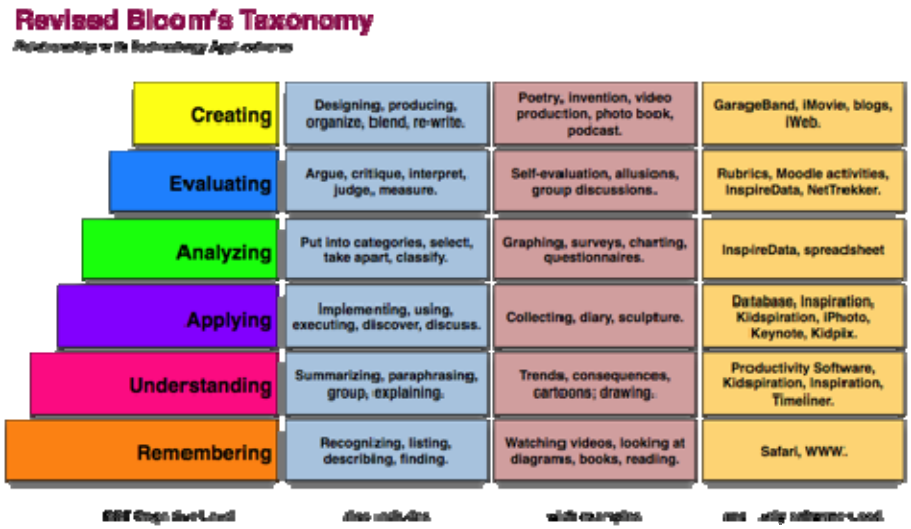
The taxonomy is set out:

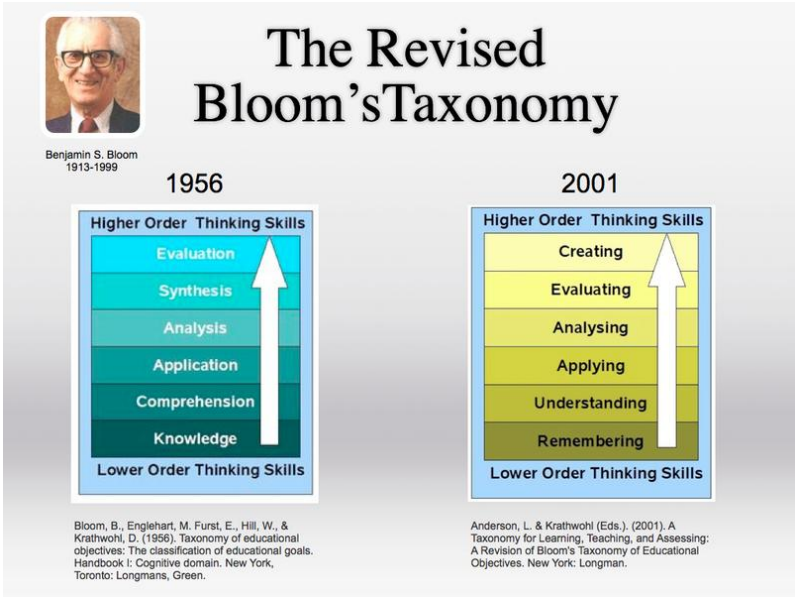
- 1.00 Knowledge
    - 1.10 Knowledge of Specifics
    - 1.11 Knowledge of Terminology
    - 1.12 Knowledge of Specific Facts
    - 1.20 Knowledge of Ways and Means of Dealing with Specifics
    - 1.21 Knowledge of Conventions
    - 1.22 Knowledge of Trends and Sequences
    - 1.23 Knowledge of Classifications and Categories
    - 1.24 Knowledge of Criteria
    - 1.25 Knowledge of Methodology
    - 1.30 Knowledge of The Universals and Abstractions in a Field
    - 1.31 Knowledge of Principles and Generalizations
    - 1.32 Knowledge of Theories and Structures

Text above taken from: http://en.wikipedia.org/wiki/Bloom%27s_taxonomy

Below are pictures taken from the web concerning Bloom's Taxonomy


BLOOMS TAXONOMY
EVALUATION
Assessing theories; Comparison of ideas; Evaluating outcomes; Solving; Judging; Recommending; Rating
SYNTHESIS
Using old concepts to create new ideas; Design and Invention; Composing; Imagining; Inferring; Modifying; Predicting; Combining
ANALYSIS
Identifying and analyzing patterns; Organisation of ideas; recognizing trends
APPLICATION
Using and applying knowledge; Using problem solving methods; Manipulating; Designing; Experimenting
COMPREHENSION
Understanding; Translating; Summarising; Demonstrating; Discussing
KNOWLEDGE
Recall of information; Discovery; Observation; Listing; Locating; Naming


Revised Bloom's Taxonomy
Creating
Designing, producing, organize, blend, re-write.
Poetry, invention, video production, photo book, podcast.
GarageBand, iMovie, blogs, iWeb.
Evaluating
Argue, critique, interpret, judge,, measure.
Self-evaluation, allusions, group discussions.
Rubrics, Moodle activities, InspireData, NetTrekker.
Analyzing
Put into categories, select, take apart, classify.
Graphing, surveys, charting, questionnaires.
InspireData, spreadsheet
Applying
Implementing, using, executing, discover, discuss.
Collecting, diary, sculpture.
Database, Inspiration, Kidspiration, iPhoto, Keynote, Kidpix.
Understanding
Summarizing, paraphrasing, group, explaining.
Trends, consequences, cartoons; drawing.
Productivity Software, Kidspiration, Inspiration, Timeliner.
Remembering
Recognizing, listing, describing, finding.
Watching videos, looking at diagrams, books, reading.
Safari, WWW.


The Revised Bloom'sTaxonomy
Benjamin S. Bloom 1913-1999
1956
Higher Order Thinking Skills
Evaluation
Synthesis
Analysis
Application
Comprehension
Knowledge
Lower Order Thinking Skills
2001
Higher Order Thinking Skills
Creating
Evaluating
Analysing
Applying
Understanding
Remembering
Lower Order Thinking Skills
Bloom, B., Englehart, M. Furst, E., Hill, W., & Krathwohl, D. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York, Toronto: Longmans, Green.
Anderson, L. & Krathwohl (Eds.). (2001). A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Longman.