# Technological literacy and entr(e/a)preneurial competencies

**Didier Van de Velde and Peter Hantson:Arteveldehogeschool university college. Belgium.**
Email: didiva@arteveldehs.be peter.hantson@arteveldehs.be

***Abstract***
*This article discusses the importance of developing a view on educating the intersection technology-work-economy. The Belgian 'TOLEON'-project developed for the Flemish region is used as a case-study to illustrate a more concrete vision on teaching entr(e/a)preneurial technology. The structure of the learning environment, the gendersensitive aspects of it and the used interpretation of practical work as a strategy for active and constructive learning are discussed. Finaly, a model for project- and competency-based learning based on sequencing heuristics is presented followed by a suitable assessment strategy.*
*Technology, economy, work and its importance*

Every day, the powerful interaction of technology, science, economy and society is clearly noticeable. West-European countries try to maintain a strong economical position in a globalising world. The last decades we can notice a descent of industrial employment due to productivity increase and capital shift towards the new developing economies (China, India, Eastern Europe, …). Since the 1970's, this shift has led in Belgium towards a proportional growth of the service-economy (De Grauwe, 2006). As innovation plays an important role in maintaining economical leadership in the world, many countries and companies raise their budget for R&D. Entrepreneurship plays an important role in a creative and job-creating economy. In Belgium, the early-stage entrepreneurship has dropped in 2006 to 2.6% (Global entrepreneurship monitor, 2007). This figure represents the number of people in the active population that are busy tot start up a business. 5% is the European average. So initiatives to stimulate entrepreneurship are high on the priority-list of Belgian politics.

Not only entrepreneurship plays an important role in today's economy, also entrepreneurial competencies in organisations (**entra**preneurship) are necessary to build dynamic, flexible, innovating and learning work-environments.

It is clear that the interaction technology-economy must play a role in our technology education curricula. It is hardly imagineable to say that learners are 'technologically literated' if they have no insight at all in relations between technology, economy and people's work in this perspective.

In many industrialised countries and regions such as France (Education technologique ,2005), Flanders (Bossaerts, B. Denys, J. and Tegenbos, G ,2003), Germany (Oberliesen, R. Schudy, J., 2003), … this idea is an engine for important renewal of the technology curriculum.

For German philosopher Günther Ropohl[1] , the aspect of work is very attached to human needs. Technology plays then a material role in an attempt to satisfy these needs. A definition of technology without this dimension is incomplete.

Advocates of a strong link between economy and technology education emphasize the role of technology as a social process. For education, entrepreneurship is an important element of inspiration:

[1] Oberliesen en Schudy, 2003. Paraphrased on p. 77.

e.g. developing creative, social and emotional skills are important not only for the future entrepreneur, but also every citizan's daily life and profession.

In Belgium, typical initiatives to promote entrepreneurship in pupils are:

- bringing entrepreneurs and managers into classrooms
- virtual business games
- setting up mini-enterprises at school
- company visits for pupils and teachers
- work shadowing
- teaching entrepreneurial competencies to manage small enterprises.
-

These initiatives are mainly oriented towards studies in trade and economy in secondary and higher education. There is no real tradition in connecting technology education with economy-work and entrepreneurship.

Building a vision on entr(e/a)epreneurial technology education
The topic of building a view on technology education and industry is not new for the Pupils' Attidute Towards Technology-conference (PATT). It has been an element of study in PATT 5 and in 1995, international examples have been developed. (PATT, 2003)

**The TOLEON-project**
This project is a Flemisch initiative for the development of tools for teaching on the intersection of technology-work and economy. It was funded by the Flemisch community in Belgium and developed by Arteveldehogeschool, a university college of Ghent university in collaboration with 4 companies specialised in educational technology. The tools are developed for key-stage 7 to 10 and do not focus on typical entrepreneurship factors such as

- having specific ideas about the marketplace or
- taking prudent risks based on a clear (market)vision.

The project focuses more on stimulating entrepreurial learing, enriching pupils' self-concept and expanding understanding on the relationships between work-economy and technology.

**Educating the intersection work-economy-technology**
Following elements played a role in developing an education tool for teaching at the intersection work-economy-technology:

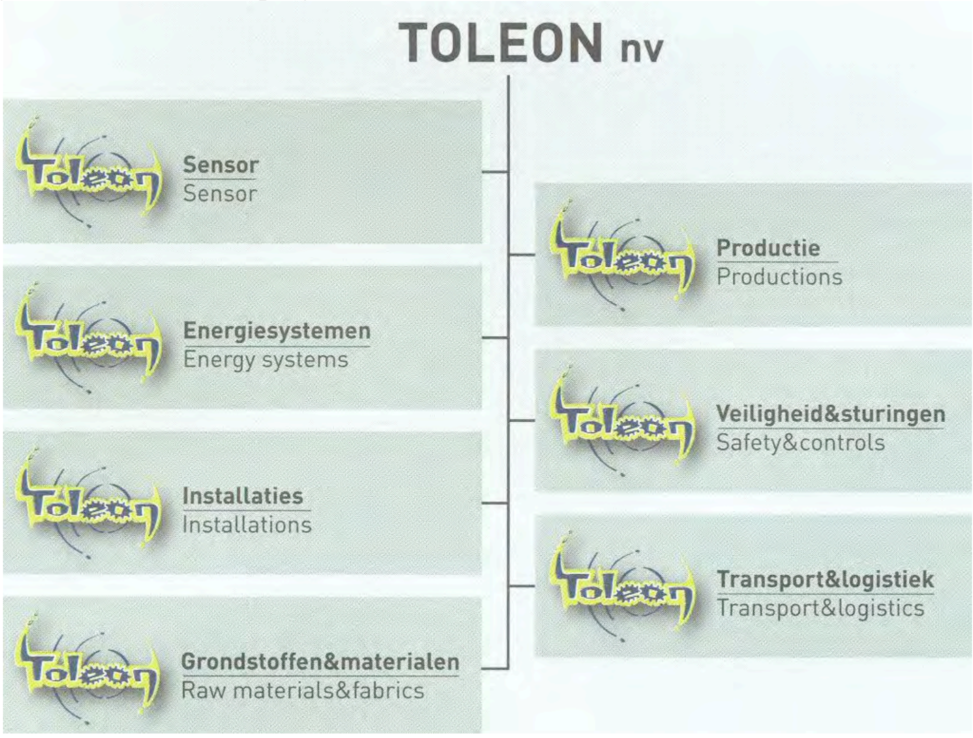
- The tension between human needs and limited resources as a common engine in economy and technology.
- Technology education as a good subject for the development of useful competencies to solve problems at home, in free time, at school, but also in simulations of the professional life. Not only the direct world of children can be addressed, also contexts derived from the world of companies and professional life can be addressed. Careful simulation of these contexts is then required. Much attention is necessary to find simplified real-life contexts that are good enough to broaden pupils horizon without risking misconceptions. As Solomon (1994), pointed out, good simulations are not simple.
- This inspiration out of the professional life can be broader than only context: making know how explicit, assessment techniques, using simple but professional materials and instruments. In France, this approach has been explored (Cliquet, J. a.o., 2002).
- Our daily interaction with technology demands several forms of problem solving: using, designing, making and analysing/researching systems, needs and phenomena; detecting errors, maintaining, … So also in authentic technology education, these competencies play an important role.
- Cooperative learning as a good setup for roleplay referring to real professions such as the operator, quality-manager, safety advisor, researcher, designer, engineer, …. Besides these more professional roles, people play specific roles in problem solving: when defining clusters of key competencies in technology such as researching/gathering knowledge, innovating, managing and executing, a link with Kolb's learning styles can be noticed (Van de Velde and Hantson, 2005).

- Learners are enriching their self-concept by obtaining information on their interests and future possibilities/abilities.
- Economic understanding based on economy as a social proces: consumers, organisations and governements making choises on the use of resources and regulation of technology (Jephcote, M. and Hendley, D. ,1994). Every choise in a design- or making-task has its economic, social and ecologic consequences. Economic and industrial understanding as an ability to make such choices and as an ability to understand how consumers, companies and governements make such choices.
- Creating learning environments where pupils are encouraged to learn in entr(a/e)preneurial way: being creative, showing leadership, taking risks, working on social and communicative abilities, learning to deal with disappointment (building a strong emotional personality). In the Flemish region of Belgium, this aspect has been modelled by Laevers and Bertrands (2003).
- Modern professional life becomes more interdisciplinary and needs a broad spectrum of competencies. The importance of key-competencies is rizing. For the TOLEON-project following clusters of key-competencies were used (De Maertelaere, S. Coulier, R. Hantson, P. en Van de Velde, D. ,2006):
  * competencies for problem solving;
  * competencies for self-regulation;
  * social and emotional competencies
  * competencies for communication
  * context- and discipline-specific competencies;

The TOLEON-project, a case study.

**The learning environment in TOLEON**

Toleon (Van de Velde, D. Hantson P. en Huyghe, B., 2006) consists of 6 cases with educational technology. The simulated company "TOLEON nv" has several business-units.




Every case stands for such a unit. A case contains text-books, interactive games on cd-rom, an introductery film illustrating the context, materials for practical work and gadgets for supporting role-play.


**Photo 1**: educational technology for learning production-competencies with the TOLEON-project.

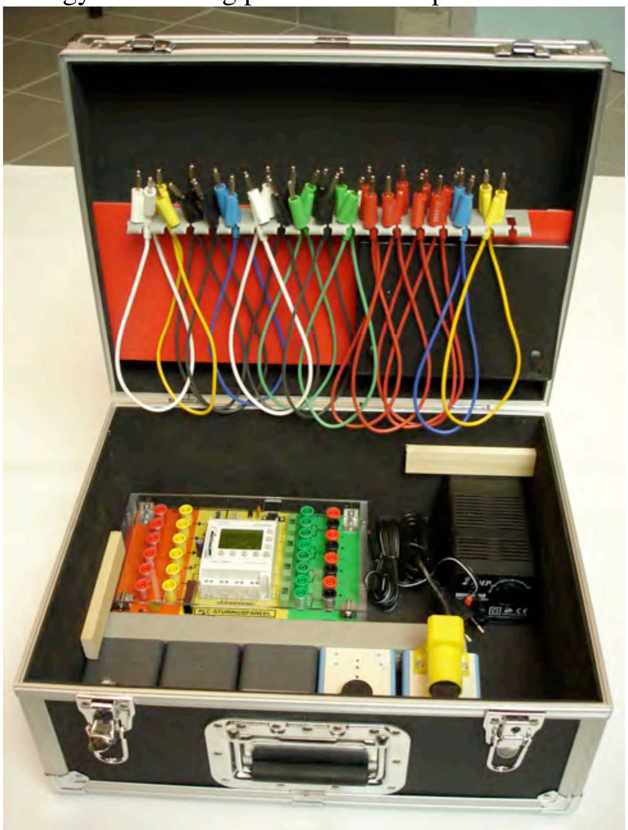


**Photo 2**: educational technology for learning technology with programmable controllers in 'TOLEON-safety&control'.

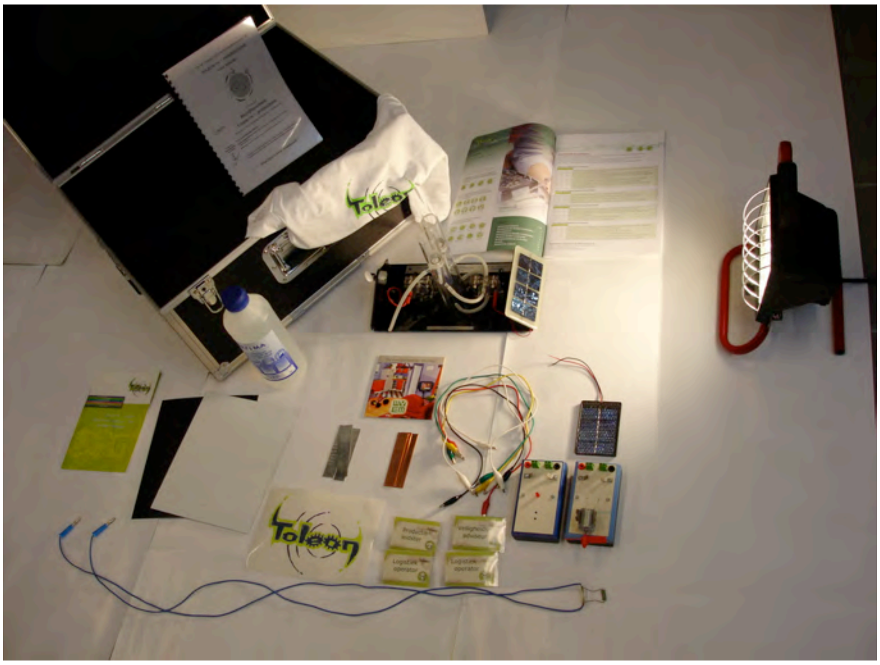



**Photo 3**: educational technology for learning technology in the business-unit 'TOLEON-energy-systems'.

**Rich contexts for learning and the world of companies**

All problem solving in TOLEON is situated by means of rich context descriptions. We've used a lot of instruments used in companies for that: e-mail prints, fax-transmission prints with order-data, checklists, simplified real-company problem discriptions, simulated company website and company visits, …

**Gendersensitive approach in TOLEON**

In order to address the central values of girls in technology education, the following points of attention were taken into account:

- gendersensitive graphics: use of neutral green as a colour in graphics referring to actual youth culture that are appealing for boys and girls
- role-pattern- confronting images and pictures with attention for the equality of females in professions.
- Learning goals for social and communicative competencies and connecting technology with creativity. Role-play as a interesting tool for developing such abilities.
- Rich contexts with attention for the interaction man-society-nature.

**An innovating approach of practicum ('practical work')**

**Defined heuristics**

In the TOLEON-project, a practicum is defined as a simulation of a real-life context-based problem-solving. Several types of problem-solving are defined and every type becomes connected with a specific heuristic structure. Special attention has been applied to avoid ritualisation. The heuristic structures are carrying the know-how for the typical competencies in technology such as designing, producing, analysing systems, ……

The structure of the heuristics are simplified and defined by 5 iterative steps/phases.

Each typical form of problem-solving in technology becomes structured by a profiled heuristic. For learners, these know-how structures are also indicated by a graphic icon.

**Icon of the covering technological process (TP)**

**Steps/phases in practical work heuristics**

For the covering technological process we defined 5 sub-heuristics (we use the word 'phase'):

1/need identification-2/design-3/production-4/use-5/effect.
Every 'phase' consist of 5 typical steps. These heuristics may not be used as algorithms forcing learners in a ritualized process. They are used as anchors respecting the learning style of pupils.

**Researching practicum (RP): gathering knowledge.**
A researching practicum can be linked to scientific work. In technology education, they play a role in generating usefull knowledge for further technological activities. By experimenting, either in group or individually, pupils gather knowledge and insights about natural phenomena, social and technological activities and systems.

**Practicum "researching natural phenomena"**
The goal is to research natural phenomena to generate knowlegde for further technological problem-solving.
**Practicum "researching needs (and limitations)"**
Practical research-activity to gather knowledge about needs, limitations and resources to support further technological problem solving such as designing.
**Instrumental practicum (IP)**

using (an instrument );

using (a manual)

Practical work as an approach to gather competencies for using technological systems. In this process of using, the manual of a technological system is an important concept. In the Flemisch region of Belgium, we can notice a lot of cognitive testing of device-specific knowledge in technology education. Therfore, for every piece of instrument or device in the set of TOLEON's educational technology, a manual is developed. So the emphasis comes on learning the competence how to use a manual when using systems. Where the other processes are more heuristic, the process of use is more algorithmic.
For learning the use of more complex systems, e.g. a programmable controller, we used half solved using-problems. This approach makes the practicum more dynamic and is a good preparation for a 'general problem solving practicum' (GEPS).

**Technology-specific practical work**

**Designing**
Practical work for the creation of a product/system/service or environment dealing with needs, limitations and resources of humans, society and nature.

attention for the making process productivity

**Producing (making)**
Practical work to produce products/ systems/ environments/ services starting from a given design and criteria. There is task-analysis, work preparation and continious improvement of proces (man-means-methods-materials- workplace). The making requires strict attention for safety, quality, ergonomics, ….

**Researching effects**
Practical work with the aim to research effects of technological developments on man, society and nature. The research practicum includes making suggestions for regulating the technological development or regulating the social context.
**Researching/analysing technical systems**

Every artefact represents a enormous amount of knowledge needed to realise it. Where mostly only the knowledge for good use of the artefact is present, this heuristic process tries to bring up futher knowledge about functions and meanings of (sub)systems and the flow of mater, energy and information.

**Problem solving (GEPS)**

Many technological problems do not have a specific profile in the sense of

designing/producing/researching, …. E.g. reparing a defect, maintaining an artifact, diagnosis and trouble shooting, …For this kind of problem solving we used a more vague general problem-solving heuristic (GEPS). Important aspects are diagnosis, finding subproblems, searching known solutions for these subproblems or transforming problems in controllable forms, testing and assessment of solutions and processes, ….

Model for authentic and competency-based learning

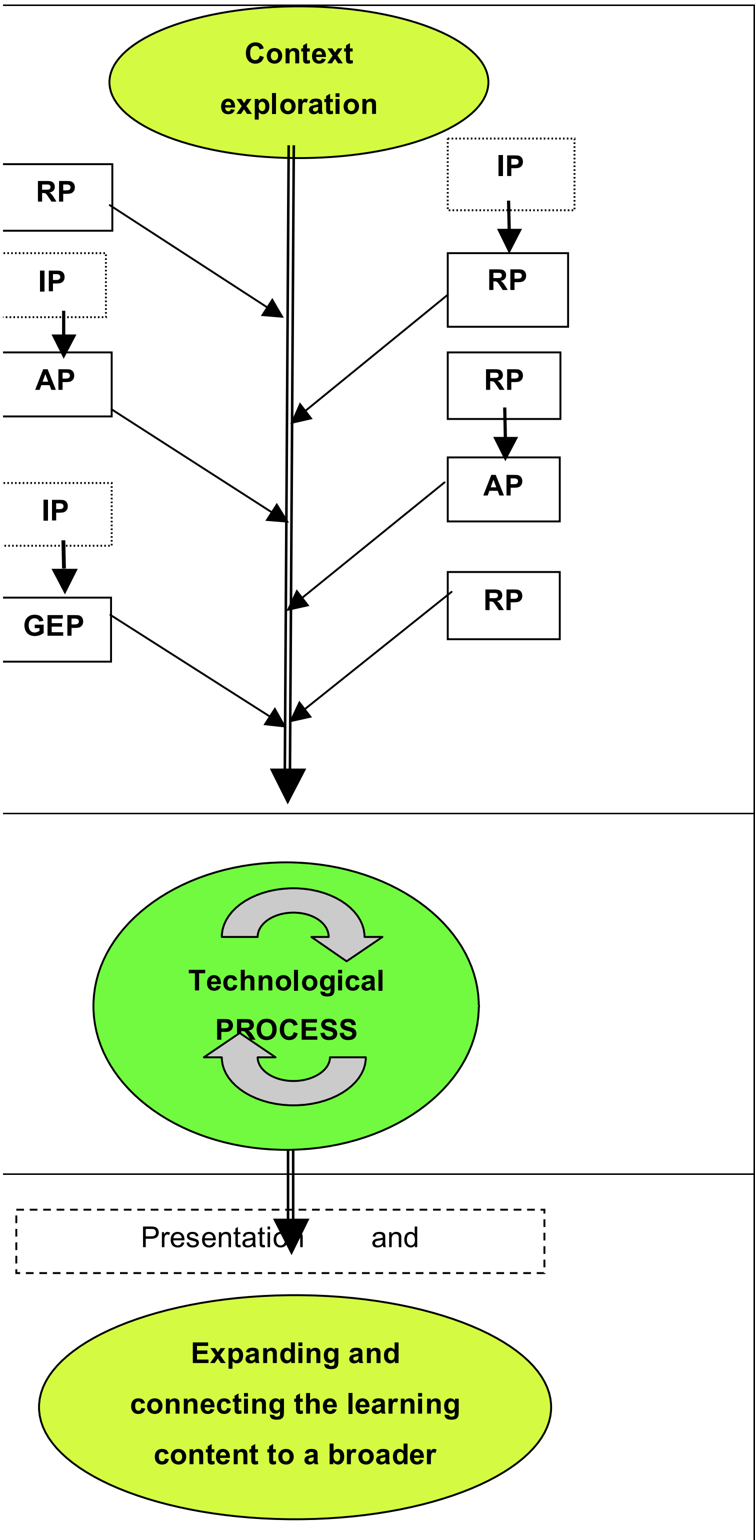
**Sequencing heuristics**

In order to construct a lesson-cycle of 6 to 9 weeks we have used a model where the specified types of practical work follow a logical sequence and a competence-based order.

In the connection phase pupils explore the context through their spheres of life: technology at home, in the community, at school, but also in private and public organisations.

In the analytical phase, learners gather knowledge and abilities needed for technological problem solving in the phase of synthesis. In this phase, a more complex technological problem has to be solved integrating the learnt elements. This technological problem (mostly a design- and production-task) is representative for the learning context and must be appealing for pupils. The expansion phase serves to open up again the perspective and shows the role of the aquired competencies in our technological world.

In TOLEON, this schedule is not a rigourous thing. E.g. in ‘Toleon safety&controll’ the analytical phase consists of a alternate succession of ‘instrumental practica’ (IP’s) where problem-based learning is focused on instrumental learning in order to use the programmable controller and ‘gereral problem solving’ (GEPS), in which the problem solving itself and programming-strategies become more important.




| | |
|---|---|
| **1.Connection phase**<br>**2.Analytical phase**<br>(3-4 weeks)<br>**RP**: researching practicum<br>**IP**: instrumental practicum<br>**AP**: applied practicum: applying knolegde in an other context<br>**GEPS**: gereral problem solving | **CONVERGENT** |
| **3. Phase of synthesis**<br>(2-3 weeks)<br>**TP**: technological process Processes: full technological proces or process zooming (= designing, producing) | |
| **4. Phase of expansion**<br>(1 or 2 weeks)<br>Besides presentation and evaluation, practical work for investigating effects is useful. | **DIVERGENT** |

Graphic model: program for teaching technology of a defined context over a 6-9 weeks period (Van de Velde and Hantson, 2003).

**The use of general systems theory in TOLEON**

- For the grades 7 to 9, simple concepts of gereral systems theory are an appealing alternative for traditional discipline-based analysis of systems (e.g. mechanic analysis, electronic analysis, hydraulic analysis, ….).

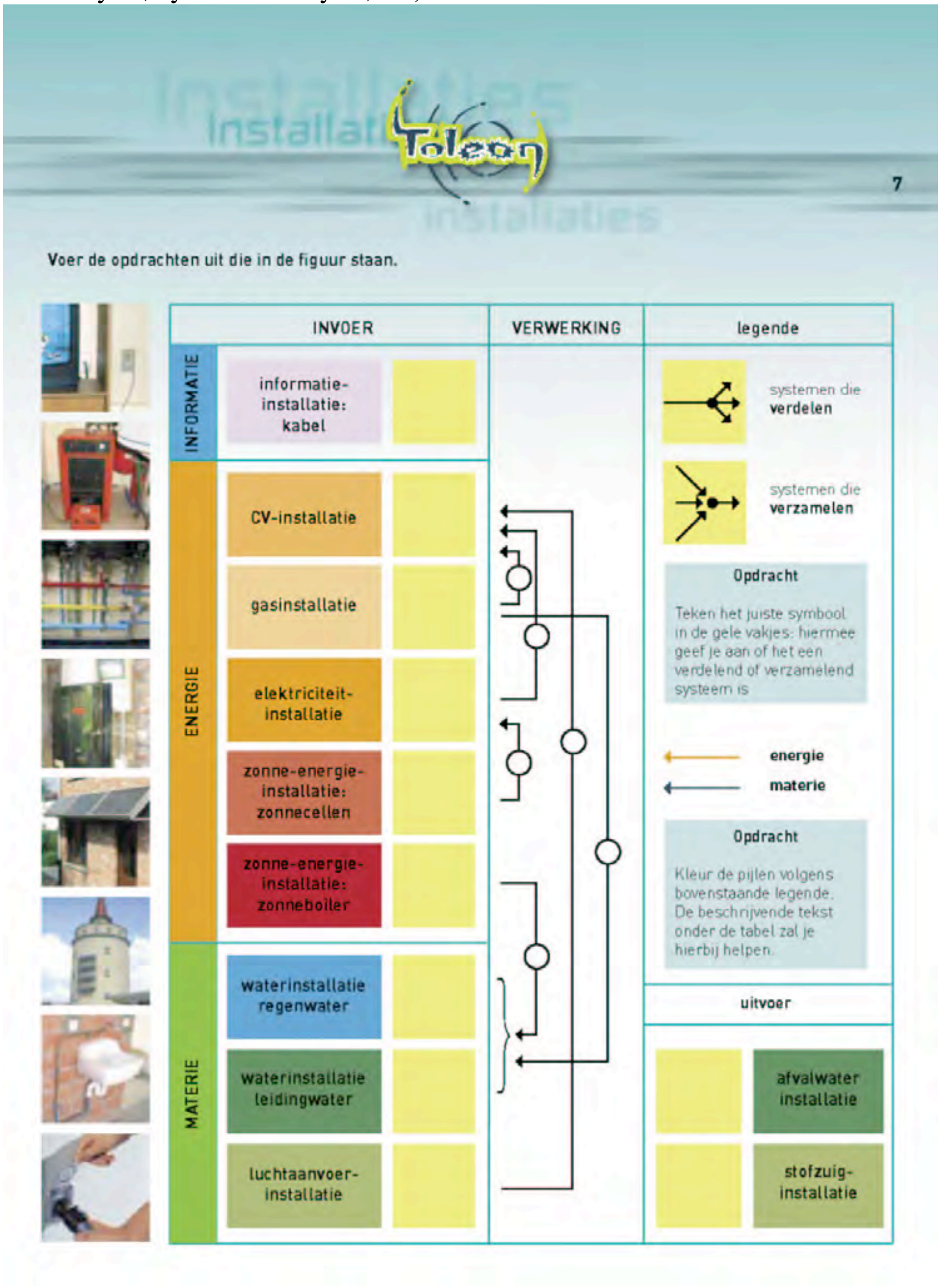



**Figure**: example of one of the general system-theory approaches used to analyse charasteristics of technical dynamic systems at home and relations between them in 'TOLEON-installations'.

We used following concepts:

- identity-cards[2] of (a group of) systems;

---

[2] Identity-cards for systems are epistemologically related to the work of 18th century-encyclopedists trying to grasp e.g. the complexity in plants and animals: trying to bring structure in our complex and diverse designed world.

- input-proces-memory-transport-output models of the information-, matter- and energyflow in technical systems;
- black boxes representing (sub-)systems;
- principles of control systems such as feedback;
- Intuitive understanding of the priciples of O- and 1-junctions and their influence on effort- and flow (as derived from Bund Graph theory).

**Assessment strategy**

In textbooks, besides a product-assessment, there is attention for process-assessment ('continuous improvement-chart' as inspired by the industry).

Learners get 360° feedback on their contribution to the learning process. There is attention for self-assessment and peer-assessment in the assessment table (see figure).

The assessed roles were developed combining input from assessment research in education (Dochy, Schelfhout and Jansens, 2003) and project management (Wijnen, Renes and Storm, 2001).

As a result, pupils can get feedback on their assignment-contributions. Ass well, they get to know something about their talents (profile-score): are they inspirators, thinkers, entrepreneurs, supporters, operators of conservators?

Teachers can attach additional observable learning goals. In the Flemish region of Belgium, a team of employers, teachers and assement-specialists have developed a rubric-scale (Union of Christian employers, 2006) with observable basic attitudes relevant for professional- and school-life.

**Assessment stategy**

……………………………………………
……………………………………………
ɔers:
……………………………………

**Conclusion**

| score | Give and receive appreciation scores. |
|---|---|
| 1 | No contribution to beter team-results |
| 2 | Low effort |
| 3 | Good effort |
| 4 | Excellent contribution to team result |

| | Appreciaton- score: | | | | | |
|---|---|---|---|---|---|---|
| ıt-chart: learn to know your talents. | Self assess-ment | Assessment of team member 1 …………….. | Assessment of team member 2 ……………… | Assessment of team member 3 ……………… | Assessment by teacher | Profile-score |
| ıave good ideas and you think about future ɛms. You are an **inspirator**. | | | | | | |
| vork very orderly following excact ctions. You are a **conservator**. | | | | | | |
| ːan explain a given situation very good, you **thinker**. | | | | | | |
| ike the hands-on work, you are an **ator**. | | | | | | |
| ake the lead and try to get things done, you n **entrepreneur**. | | | | | | |
| ry to help where possible and you are ɛrned to keep everyone motivated. You are **ɔporter**. | | | | | | |
| ……………………………………………… . ːrvable competencies, added by the er.) | | | | | | |
| ːrvable competencies, added by the er.) | | | | | | |
| **score:** the appreciation of your work | | | | | | |

This article illustrates the importance of teaching on the intersection technology-work-economy. It describes a concrete development of an education concept and its supporting educational technology for teaching entrepreneurial technology for grades 7 to 10. The project pays attention for gender aspects, situates the learning content in contexts, uses several approaches for simulation and authentic learning. For competence-based learning and the development of meta-cognition, a concept of sequencing heuristics was developed. Also a suitable assessment strategy was defined. We can conclude that educating on the intersection technology-work-economy is not contradictory with modern views on eduction. The project TOLEON shows us a clear link with technological literacy as defined in the USA-standards, far beyond the influence of vocational technology on gerenal technology education.

**References**


Bossaerts, B. Denys, J. and Tegenbos, G.(ed.) (2003). *Emphasis on talent, an integrated vision on working and learning (Accent op talent. Een geïntegreerde visie op leren en werken)*. Antwerp. Garant. 130p. (Dutch publication).

Cliquet, J. e.a. (2002). *La demarche de projet: de l'entreprise au collège*. Paris. Delagrave. 271p. (French publication).

Coulier, C, Hantson, P. en Van de Velde, D. (2004). Oriento, *Gendersensitive orientation towards choice of study and occupation in general technology education (genderneutrale studie- en beroepskeuzeoriëntatie in technologische opvoeding)*. Gent, Arteveldehogeschool university college. Internet: www.oriento.be. (Dutch publication).

De Grauwe, P. (2006). *The future of our economy. (Waar gaat het naartoe met onze economie?)*. Tielt. Lannoo. 242 p. (Dutch publication).

De Maertelaere, S. Coulier, R. Hantson, P. en Van de Velde, D. (2006). *Heroes of every day, genderneutral choise of study in Flemish key-stage 5 and 6*. ESF/VESOC-project. Ghent. Arteveldehogeschool university college. (Dutch publication).

Dochy, F. Schelfhout, W. Jansens S. (red). (2003). *Assessment in education*. Tielt. Lannoo. 136p. (Dutch publication).

Dunon, R. and Van Driessche A. (2001). *Defining and selecting key-competencies in Flanders*. Brussels, Ministry of the Flemish community –Department.of education.

Education technologique. (2005) *Technologies et milieux du travail*. No 27. Paris. Delagrave. (French publication).

Global entrepreneurship monitor. (2007). Internet: http://www.gemconsortium.org (retrieved January 2007) (GEM country summaries – Vlerick Leuven Ghent management school).

International Technology Education Association.(2000). *Standards for technological literacy: content for the study of technology*. Reston, VA: Author.

Jephcote, M.; Hendley, D. (1994). *How design and technology can contribute to the development of pupils' economic and industrial understanding in Teaching Technology*, edited by F. Banks. New York. Routledge. The open University. 253p.

Laevers, F en E. Bertrands, (2003), *Conceptmodel entrepreneurship version 2003* (developped for equalproject STEP), Leuven: Center for experience based education, Catholic University of Louvin. See also internet: http://habe.hogent.be/step/

Mottier, Raat and DeVries. (1991). *Technology education and industry*. PATT-5 conference. VOL.1.

Oberliesen, R. Schudy, J. (2003). *Work Oriëntation-Concept of Technology Education in Germany* in *Technology education, international concepts and perspectives*. Edited by Graube, G. Dyrenfurth, M. and Theurerkauf, W. Frankfurt am Main, Peter Lang. 345p.

PATT (1995). *Technology, entrepreneurship and employment: international examples of lessons for teaching entrepreneurial and employment aspects of technology*. Delft. Technon.

Solomon, J. (1994). *Teaching Science, Technology and Society. Games, simulation and role-play*. in Banks, F. (ed) Teaching Technology. New York. Routledge. The open University. 253p.

Van de Velde, D. Hantson, P. (2005). *From dualism towards an emphasis on talent*. Proceedings of the PATT-conference. Haarlem.. Internet: www.iteaconnect.org/PATT15/PATT15.html. Also published in. De Vries, M. , Mottier, I. The international handbook of technology education, reviewing the past twenty years. (pp. 377-387). Rotterdam/Taipei: Sense publishers. 2006.

Wijnen, G. Renes, W. en Storm, P.(2001) *Project management (projectmatig werken)*. Utrecht. Het Spectrum. 269p. (Dutch publication).

Van de Velde, D. Hantson P. en Huyghe, B. (2005). *TOLEON, developing talent for technology and entr(e/a)preneurship*. Ghent. Arteveldehogeschool university college. Internet : www.toleon.be.