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T-shaped competency profile for water professionals of the future

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Abstract

Global environmental changes expose future university graduates in hydrology and related fields to problems of unprecedented complexity and magnitude. The T-shape model is proposed as a generic competency profile guiding the design of university curricula. This model differentiates between cognitive competencies in a certain field, (i.e. hydrology; vertical leg of the T) other cognitive/knowledge competencies in neighboring fields (e.g. hydraulics, aquatic ecology, land use management etc.) and functional, personal and values competencies and meta-competencies (horizontal bar of the T). It is based on the holistic model of professional competencies by Cheetham and Chivers (1996) and related studies (Oskam, 2009). The T-shape profile should apply to all levels of higher education (1st degree till doctorate level) in hydrology and related fields. For the effectiveness of hydrologists as professionals a variable mix of competencies is required and further discussed. Key aspects are an open attitude for learning, continuous professional development (life long learning), and integrative and team working skills. Furthermore, a stimulating learning environment that promotes active learning is essential. As examples that substantiate the proposed T-shape model, the post-graduate education programmes of UNESCO-IHE and the main outcomes from a university curriculum workshop to promote education for sustainable development are introduced.

1 Introduction

Global environmental changes will expose the future university graduates in hydrology and related fields to water problems of unprecedented complexity and magnitude (e.g. Wagener et al., 2010; Weiler, 2007; Uhlenbrook, 2007, 2009). In relation to this, employers of water professionals expect their staff to continue learning throughout their professional lives to keep abreast with the latest knowledge and skills in the water sector. Not only for employers, but in particular for the individuals themselves and

HESSD
9, 2935–2957, 2012

universities continuous professional development is essential and beneficial (e.g. Megginson and Whitaker, 2003). To deal with these challenges and to develop sustainable solutions new knowledge, skills and attitudes are required for university graduates in water-related disciplines to be optimally prepared for the future. As stated in the Dublin descriptors, graduates of Master programmes need to have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous. There is growing evidence that people, who take initiative in learning, learn more and learn better than those who do not. The evidence is also that they learn more deeply and the learning outcomes remain more permanently (Knowles, 1975).

UNESCO-IHE Institute for Water Education is an international post-graduate education institute that implements MSc programmes (no undergraduate programmes), a PhD programme, several project related post-doctoral programmes and also short courses for professionals ("continuous professional development programme") in the field of water and environment; see http://www.unesco-ihe.org for further details. As an UNESCO Institute, the vision of the institute is contribute to a contribute to "*a world in which people manage their water and environmental resources in a sustainable manner, and in which all sectors of society, particularly the poor, can enjoy the benefits of basic services*". The development relevance of the Institute is also stated in the Institutes mission to "*contribute to the education and training of professionals and to build the capacity of sector organizations, knowledge centers and other institutions active in the fields of water, the environment and infrastructure in developing countries and countries in transition*" (see http://www.unesco-ihe.org). Contributing to change and development through academic water education in the so-called global South is a particular challenge. Noteworthy, the student population of UNESCO-IHE (i.e. ca 180 MSc students per year, 130+ PhD students, 20+ post-doc and many short-course participants (>500 per year)) is very diverse in terms of country of origin, ethnical, cultural and religious backgrounds as well as in knowledge and academic training before they start their programmes. This all requires careful considerations regarding the contents and design of the curricula and the way of delivery of educational programmes. The

HESSD
9, 2935–2957, 2012

ideas that led to this paper originate from a recent internal reform process, that formulated a new vision for education, research and capacity development (UNESCO-IHE, 2011).

In 1987, Donald Schön in his now classical book developed the concept of the "reflective practioner", which characterizes a professional who is able to constantly improve his/her professional skills and abilities, through a process of explicit reflection. This seems to be an attractive concept for university graduates in the field of water and environment (including hydrology in wider sense) in a changing world. But, how can university research-based education better be linked to the practice, and what is needed to make students self-directed learners? How can graduates be best prepared to be efficient and effective as professionals? Which competencies and skills are needed most?

The objective of this paper is to address these questions and to propose a suitable generic profile for university graduates of the future. Due to the nature of the matter and the fact that it is impossible to provide empirical evidences for the suitability of the proposed profile, this paper has to be considered as a conceptual or opinion paper.

2 Professional competencies following Cheetham and Chivers (1996) and beyond

The "holistic model of professional competence" introduced by Cheetham and Chivers (1996) unifies well-recognized approaches in the field of professional education including the UK Vocational Qualifications ("outcomes approach") and the "reflective practitioner approach" by Schön (1987). It stresses the fact that beside functional competencies also personal competencies need to be built during education programmes to equip the graduates well for future challenges. In addition, the role of reflection – the ability to learn through and within practice – is central.

The model distinguishes four key components of professional competence that can be summarized as follows (see Cheetham and Chivers, 1996 for further details):

HESSD
9, 2935–2957, 2012

1. *Knowledge/cognitive competence:* the possession of appropriate work-related knowledge and the ability to put it into effective use; e.g. theoretical/technical knowledge of hydrology and hydraulics, tacit knowledge, procedural knowledge of finances or projects, contextual knowledge of geography or technology etc.
2. *Functional competence:* the ability to perform a range of work-based tasks effectively to produce specific outcomes; e.g. occupation specific skills like report writing, IT literacy, budgeting, project management etc.
3. *Personal or behavioral competence:* the ability to adopt appropriate behaviors in work-related situations; e.g. self-confidence, control of emotions, listening, objectivity, collegiality, sensitivity to peers, conformity to professional norms etc.
4. *Values/ethical competence:* the possession of appropriate professional values and the ability to make sound judgments; e.g. adherence to laws, social/moral sensitivity, confidentiality etc.

Furthermore, Cheetham and Chivers' model describes meta-competencies that connect the four key components of professional competencies, such as communication, creativity, analysis, self-development, ability to learn continuously etc. Each core competence is made up of various constituents that all interact to produce specific outcomes. The latter could be overall indicators of professional performance (e.g. successfully finished projects, efficiently run water consultancy, fulfilling all requirement of senior administrator in a water department, recognition by colleagues) or outcomes of very specific activities (e.g. installation of flood modeling software, economic analysis of a hydropower dam, assessment of currently predominant water rights in a given country/river basin).

2.1 Variable mix of competencies

Each occupation of a water professional requires a certain mix of competencies (Fig. 1) that can even vary for the same occupation depending on the cultural, socio-economic

HESSD
9, 2935–2957, 2012

and other professional settings. The individual competence mix of a given water professional is usually unequally developed, depending on the personality, training and education received and professional experiences.

2.2 Continuous professional development

The knowledge base in almost every discipline is increasing rapidly. The development of new technologies are happening with accelerating speed and the time till some specialized knowledge is outdated is getting shorter and shorter. The only constant factor at professional level is change. It is no longer sufficient to be a good water professional in one field (e.g. hydrology, hydraulic engineering, water law, water economics, hydrological modeling etc.), a professional who learned his/her profession once. It is needed to learn continuously throughout the professional life to keep up-to-date with the latest knowledge and developments in the water sector (life-long learning or continuous professional development, CPD). Therefore, different requirements (knowledge, skills and attitude) are being demanded from the graduates of the future. Consequently, an essential skill for graduates in these times of change is that they are able to manage their professional competence development, which requires the key skill for professional success: to learn how to learn.

Another aspect is that the necessary mix of competencies changes of an individual change during the professional career. This can be caused by reaching higher levels in a given profession, i.e. a position with larger management and leadership responsibilities, which requires for instance more and different functional and personal competencies. Additionally, change of the occupation usually requires some changes of the mix of competencies.

2.3 Multiple competencies needed in teams

Nowadays, professionals in particular with an academic background never work in an isolated environment. The complexity of problems related to current and future water

Discussion Paper | Discussion Paper | Discussion Paper | Discussion Paper |

HESSD
9, 2935–2957, 2012

Competency profile for water professionals

S. Uhlenbrook and E. de Jong

resources management makes it impossible for one person to have all the necessary competencies to be able to deal with all aspects of the problems and to develop suitable solutions. To still accomplish successful water resources management, a team needs to be composed of individuals with a variety of specialized competencies. For instance, a river basins planning problem will require the services of

– a hydrologist, e.g. for assessing the physical water resources and its variation in space and time under current and future circumstances,

– a limnologist, e.g. for interpreting and predicting the factors defining the health of the rivers and lakes,

– a hydraulic engineer, e.g. for assessing existing and newly required hydraulic structures,

– a land use specialist, e.g. for evaluating existing land use practices and possible developments for the future,

– a water economist, e.g. for examining the economic consequences of proposed policies, and

– a water governance expert, e.g. to for assessing existing and advising on more effective institutional arrangements related to the water sector in the study area.

Even more expertise and persons might be needed for a certain project, which will depend largely on the complexity of the problem and the extent of integration of the required solutions. In particular in fields where innovation is important, more and more work is done in interdisciplinary teams. This is truly the case for many water management problems, that are often complex and demand integrated and adaptive solutions. However, regardless of the number of people in the team and the depth of their specialized knowledge, together they will not get anywhere if they do not effectively work

HESSD
9, 2935–2957, 2012

together. Finding a common language, understanding the basics of the other disciplines and being able to integrate outside specialist's knowledge are essential skills for successful team work.

3 The proposal: T-shaped competency profile for water professionals

3.1 Definition of the T-shaped competency profile

Considering the global environmental changes and the other external and internal drivers influencing education and required competencies, led to the proposal that the water expert of the future – independent of his/her background in engineering, earth and natural sciences or social sciences – should be someone whose knowledge, skills and understanding of the context of the work enable him/her to face the future water challenges and to cooperate with other disciplines. This requires a T-shaped competencies profile for the graduates of future (Fig. 1a). The vertical leg of the T stands for the solid knowledge in one discipline such as hydraulic engineering, hydrology, aquatic ecology, economics, (water) chemistry, microbiology, informatics, sanitary engineering, environmental policy and law, agronomy etc (mainly knowledge and cognitive competence, cf. Sect. 2). However, this is not enough for an effective professional. The horizontal bar of the T stands, on the one hand, for knowledge and cognitive competence outside the own discipline, on the other hand, for functional, personal and values/ethical competencies as introduced by Cheetham and Chivers (1996). A basic understanding of adjacent disciplines and other professional knowledge and skills in complementary fields such as general business, entrepreneurship and selected soft skills (e.g. project management, leadership, negotiation skills, people skills, right-brain skills, conflict resolution, networking skills) are needed (e.g. Mollinga, 2007; Oskam, 2009; Kaspersma et al., 2012). Having an appropriate mix of all these competencies (usually achieved through complementary team members) is necessary to tackle novel

HESSD
9, 2935–2957, 2012

complex challenges, to analyze multiple components, to identify emerging properties, systems and patterns, and to synthesis the big picture.

The T-shape profile should not be confused with the profile of a generalist (Fig. 2b). The ideal T-shape graduate is a top expert in one field but he can build bridges to other disciplines and is able to think out of the box. A generalist's profile is characterized by a general knowledge of a wide range of disciplines (each to varying extent), but not by an in-depth understanding of one discipline. This might be the preferred profile if the water related expertise in a certain region is very low and the water education is at its early stage, as for instance during the setting-up phase of the general MSc programmes in IWRM in least developed countries as, for instance, the WaterNet programme in Southern Africa (Van der Zaag et al., 2012) or the WREM programme in Rwanda at the National University of Rwanda. However, this does not necessarily mean that T-shaped water professionals would not be needed or less effective under these circumstances. The profile of a specialist ("I-shaped" profile; Fig. 2c) is predominantly of mono-disciplinary nature, and is up to date widely applied at universities worldwide.

Due to the basic understanding of neighboring disciplines (part of the horizontal bar of the T), T-shape professional should be able to understand well the potential and limitations of neighboring disciplines to provide inputs to the solution of interdisciplinary problems. This usually starts with careful listening to and communicating with team colleagues and, last but not least, the demand side that needs a solution to the problem. Coupled with the right working attitude and "enabling environment" (e.g. Alaerts and Kaspersma, 2009), T-shaped water professionals will be able to explore insights into water problems from many different perspectives, and contribute to the development of creative, integrated and sustainable solutions. Thus, they have essential parts of the baggage needed to become future water leaders rather than followers. One T-shape does not fit all! Individuals have different interests and abilities to develop their disciplinary competence (vertical leg) and other competencies as summarized in the definition of the horizontal bar. For an effective organization, it is important to have staff with different T-shapes and the right mix of competencies to maximize the coherence of its human capacity.

3.2 Problem solving in teams of T-shaped professionals

Future working modes will require increasingly cooperation in groups containing of experts from a variety of disciplines (e.g. Hackman, 2002; Woolley et al., 2010; see also discussion in Sect. 2). Finding a common language, having a basic understanding of other disciplines and being able to integrate specialist's knowledge is crucial for successful group works. T-shaped professionals are well prepared to work in groups. When they are put together in a team, their horizontal bars overlap (Fig. 3a) even if the individuals have different breadths and depths of their vertical and horizontal bars. Ideally, their combined base is wide enough to cover the all domains related to the problem that they are jointly addressing. Thus, they have a common language and shared knowledge and skills that will enable them to work together and to jointly tackle complex water problems, which cannot be solved by one individual who is strong in only a single discipline. In a group of predominantly I-shaped professionals (Fig. 3b) it has be observed repeatedly that the process of understanding each other, finding a common language and integrating knowledge from all experts in the team is often a very lengthy process and can often not be reached. Often the collaboration of experts in disciplines that are relatively close (e.g. different natural scientists, engineers or expert with a social sciences background) works well, which is illustrated by vertical bars that are closer to each other in Fig. 3b, middle. However, the cooperation in truly inter-disciplinary groups (characterized by group member with various disciplinary backgrounds) remains usually very difficult and inefficient.

The effectiveness of groups jointly has been studied by many researchers (e.g. Hackman, 2002). However, we consider the work of Woolley et al. (2010) as major breakthrough as they could demonstrate and quantify the main influences on the so-called collective intelligence. They carried out two studies in which 699 persons were randomly grouped into small groups (2–5 persons) and ask to do different tasks such

HESSD
9, 2935–2957, 2012

as: (i) visual puzzles, brainstorming, collective judgments, and negotiating over limited resources, and (ii) architectural design task after complex research and development problem. Though not directly related to water, all these tasks require different skills and competencies for the individual and the team as a whole that seem quite relevant for many water professionals. Based on these experimental studies, the authors provided evidence for a general collective intelligence factor ("c factor"). Thus, one plus one can be greater than 2 if teams are functioning well. Furthermore, they could show that the group performance is not strongly correlated with average or maximum individual intelligence of group members. Thus, having one very intelligent individual in the group does not guarantee overall good group performance. However, they found that the group performance is correlated with the

1. social sensitivity of group members (being able to "read the mind in the eyes"),
2. equality in speaking turns (conversation not dominated by one or a few people), and
3. proportion of females in the group (mediated by social sensitivity).

4 What does the T-shape competency profile mean for the education of water professionals?

The T-shape competency profile rejects a "one programme fits all approach". Students need to get the chance to develop individually in the various components. Some students prefer to develop more towards a generalist (shorter vertical leg, but broader horizontal bar); others have a strong interest in their main discipline in which they specialize (long leg, but narrower horizontal bar). However, all students should develop their (variable) T-shape during their time at university. Thus, every graduate has a main discipline in which he/she has in-depth knowledge but has also learned to develop the other required competencies (horizontal bar). In particular the latter will often be further

HESSD
9, 2935–2957, 2012

developed after graduation as practicing professional. This needs to be considered in the content, format and delivery of tertiary water education programmes.

4.1 Make flexible learning paths and groupworks part of the curricula

Programme curricula must allow flexibility to serve the participants' interests in terms of breadth and depths and to trigger passion and curiosity. Curricula must offer the possibility for students to select a number of courses of their own choice outside the compulsory programme.

The work of Woolley et al. (2010; see above) demonstrates that groupworks are essential components in university curricula. This seems to be particularly true for water education that often requires the development of integrated solutions in interdisciplinary teams (see Sects. 2 and 3). Furthermore, groupworks have to be facilitated well, and ideally the groups should be gender balanced what is a challenge in many hydrology programmes due to imbalanced student population.

4.2 Open attitude for learning

In all graduate and post-graduate programmes it is important to stimulate an open atmosphere so that students enjoy learning. Continuous education is the prerequisite to keep pace with the quickly changing world, which connects to the essence of life-long learning as discussed above. An open attitude to new knowledge should be created which includes the ability to internalize recent research results. An openness also to water-related knowledge from outside the own disciplinary field should be created. The open attitude will also facilitate the honest discussion of issues that are often considered as delicate in a multi-facet setting, such as engineering ethics, uncertainty of predictions, equity issues, gender issues, corruption in the water sector, etc.

4.3 Stimulating learning environment

The learning environment should be such that the surrounding facilities and the lectures enable to develop passion for the selected academic field and curiosity that drives the students' will to learn more and to find out new things. Lecturers will have to play different roles in that process, i.e. the role as classical teacher during introduction lectures, as mentor and resource person during exercises and assignments, and as supervisor and co-researcher during research projects. It is important that they connect as much as possible with the students and demonstrate dedication and passion for the subject to inspire them to go further in the learning process. The facilities have to support that process by enabling a problem-based and active learning environment. Suitable lecture rooms with equipment that stimulate lecture-student interactions (e.g. smart boards, video-conferencing etc.) as well as laboratory space and facilities that allow learners to experiment are helpful in this endeavor.

4.4 An adaptive, flexible and self-learning organization – challenges for the university itself

Remaining a high-impact and cutting-edge water education institute (likely not limited to water only) requires, on the one hand, that the content, format and delivery of the education are top and constantly evaluated and assessed. Staff development and training activities (e.g. University Teaching Qualification programmes) should have high priority; Pathirana et al. (2012) demonstrated it impacts on water educators. On the other hand, a system needs to be in place to identify international developments in the water sector and related fields, and to respond to changing demands in the water sector. This requires pro-active mechanisms to signal such developments and changes in the education and research related demands, and the organizational capacity to adapt to these developments and changing demands.

In such a flexible and adaptive system, it is important to remain in a continuous dialogue with important stakeholders, current and future students and alumni about

HESSD
9, 2935–2957, 2012

the educational needs and demands of water professionals. Ideally, a system is also required in which the impacts of education are continuously monitored and assessed also with the aim of optimizing existing programmes. Therefore, excellent lectures with a good sense for disciplinary developments and a wider perspective for relevant other fields and society are needed. Additionally, this can be supported by a system to obtain feedback from alumni and water professionals. Finally, mechanisms need to be in place to ensure that this feedback is acted upon, what requires good leadership from various actors such as the education programme committees, academic affairs departments, rectorate etc.

5 Case studies

5.1 Case one: implementation of T-shaped model in MSc programmes at UNESCO-IHE

UNESCO-IHE in Delft, The Netherlands, continues the work that was started in 1957 when IHE first offered a post-graduate diploma course in hydraulic engineering to practicing professionals from developing countries (further details at http://www.unesco-ihe.org). The backbone of the Institute is the MSc programmes in the fields of:

- Environmental Science (ES)
- Municipal Water and Infrastructure (MWI)
- Water Management (WM)
- Water Science and Engineering (WSE)

Every programme consists of a number of specializations, e.g. within the Water Science and Engineering programme a student can opt for the specialization Hydrology and Water Resources (duration: 18+ months). The graduates are awarded a Master of

HESSD
9, 2935–2957, 2012

Science degree in the programme and specialization of their own choice. In addition, several joint MSc programmes (leading to joint or double-degrees) are offered with universities worldwide. All programmes are set up following the T-shape model and competencies of both the vertical and horizontal bar of are addressed. This applies for the Delft-based MSc programmes and the joint MSc programmes (e.g. McClain et al. 2012) as well as the PhD programme of the Institute.

All four programmes start with a common introductory week on “water and sustainable development”. Students from all different disciplines and different backgrounds are mixed and follow a common programme in which they do different groupworks and individual assignments. This week is followed by a common period for each programme of 6 to 12 weeks (duration differs per programme). Thus, in the WSE programme hydrologists, river engineers, coastal and port engineers, irrigation and drainage engineers and hydroinformaticians follow a common programme. Only during the subsequent specialization phase students start deepening their knowledge in a certain specialization (predominantly the vertical leg of the T-shape model). At the end of the specialization phase students are offered the possibility to select a number of topics outside their own specialization (elective courses, mainly horizontal leg but with vertical components), which includes topics that are not directly related to their own discipline. In the 3-4 weeks groupwork module students from different specializations are working together in solving a real-world problem, and each student is assigned a different role in the group (e.g. hydrologist, river engineer, land use specialist, coastal engineer etc.). During the whole programme several excursions and fieldworks are organized and the students are confronted with real-world situations. The hydrology students carry out two weeks of intense field work including staying on site in a catchment in Southern France.

In the last part of the programmes students have to carry out an individual research work of 6+ months resulting in an MSc thesis. Throughout the programme assessments are organized in different ways including written examinations, oral exams,

HESSD
9, 2935–2957, 2012

essay/report writing, (group) presentations, etc. This stimulates also the development of personal and professional competencies (i.e. horizontal bar of the T-shape model).

As indicated in previous chapters it is essential that graduates are able to keep abreast of the latest knowledge in their field and that they are able to work in teams efficiently and effectively. This has to be reflected didactical approaches. To enhance active learning by the students, lecturers are trained in "constructive alignment" which starts with the notion that the learner constructs his or her own learning through relevant learning activities (Pathirana et al., 2012). The lecturers' job is to create a learning environment that supports the active learning activities appropriate to achieving the desired learning outcomes. The key is that all components in the teaching system – the curriculum and its intended outcomes, the teaching methods used, the assessment tasks – are aligned to each other. All are tuned to learning activities addressed in the desired learning outcomes (Biggs, 2003). A web-based learning environment (Moodle) is used for placing lecture material, forum discussions, games, models, blogs, wiki's, movies, group assignments etc. To stimulate group activities students are offered group assignments. Everywhere in the UNESCO-IHE premises facilities are created to carry out these active learning activities: several small groupwork workplaces, wireless network, a good library and all lecture rooms are equipped with smart boards etc. In addition, all students receive at the first day a laptop with pre-installed software and lecture material (course notes, PPT presentations etc.) needed for the course work. Plenty of additional material is available via the Moodle learning environment.

5.2 Case two: outcomes of workshop on university curriculum development, H2020 project (Athens, Greece, 12–13 December 2011)

Within the H2020 Capacity-Building/Mediterranean Environment Programme, which is part of Horizon 2020 Initiative (www.h2020.net), a workshop was carried out entitled "Revisiting University Curricula: are the H2020 priority areas appropriately reflected?".

In total more than 60 participants gathered for two days; participants were mainly senior university officers and professors including (vice-)rectors, deans, education experts

HESSD
9, 2935–2957, 2012

etc. of universities in Mediterranean region. The objectives were to streamline H2020 priorities into university curricula of the region, and to develop jointly with a number of partners a new MSc programme on Education for Sustainable Development (ESD).

1. An interactive session with breakout groups on the T-shape competency profile was carried out. After an introduction lecture entitled "Capacity building for sustainable development of water resources – What are the key competencies for students?", the participants worked in small groups on questions addressing the suitability of the T-shape model for an ESD programme, and ways to implement. The main outcomes of this exercise were: there was an overall agreement on the T-shape configuration for curriculum design at universities. The focus on the main cognitive competencies of a certain field (vertical leg) is indispensible for university education, while acknowledging the need for other cognitive/knowledge competencies as well as functional, personal and values competencies.

2. Different programmes and students will have distinct T-shapes, based on the learning outcomes, country/cultural setting as well as educational background and personal preferences/interests of the learner (not one model fits all). This is essential to consider in the curriculum design (mandatory courses vs. flexibility in curriculum).

3. While all levels of university programmes should follow a T-shape, it was concluded that the first degree (usually BSc programme) should have a broader base with many subjects (wide horizontal bar with a short leg of the T), and the second degree (usually MSc programme) should have a stronger specialized competency profile (longer vertical leg of the T, but somewhat narrower horizontal bar). The same is true for post-MSc education (doctoral programme, research based; cf. Weiler, 2007) that obviously includes very advanced and specialized training, but should also include the development other skills and competencies (horizontal bar) that are essential for the future professional development of the student.

4. Key competencies are integration between knowledge fields and communication.

HESSD
9, 2935–2957, 2012

5. Mobility of the students and staff (e.g. university exchange programmes) was considered as a very important component to assure the full development of the T competencies. In addition, learning through real world cases should have high priority (e.g. field trips, visits of sector organizations, use of applied cases in problem based learning etc.).

6 Concluding remarks

Future university graduates in hydrology and related fields will be exposed to problems of unprecedented complexity and magnitude through on-going global environmental changes. To prepare them in an optimal way, the T-shape model is proposed as a generic competency profile. It is proposed that it should apply to all levels of higher education (1st degree till doctorate level). The T-shape model is based on the holistic model of professional competencies from Cheetham and Chivers (1996) and related studies (e.g. Oskam, 2009; Kaspersma et al., 2012). It is important to note that the T-shape has to be variable and flexible at the different levels of higher education (breadth vs. depths), and should reflect the different learning outcomes of a given hydrology programme and the disciplinary setting (e.g. engineering vs. earth sciences faculty), the background and interest of the students and the wider cultural setting.

To ensure effectiveness of hydrologists as professionals a variable mix of competencies is necessary that is likely changing during the professional development of an individual. Therefore, an open attitude for learning, the ability to learn and continuous professional development (life long learning) are key aspects of a suitable competency profile of a hydrologist. Furthermore, to be able to work efficiently and effectively in teams and to be able to integrate between knowledge fields are crucial.

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HESSD
9, 2935–2957, 2012

Competency profile for water professionals

S. Uhlenbrook and E. de Jong

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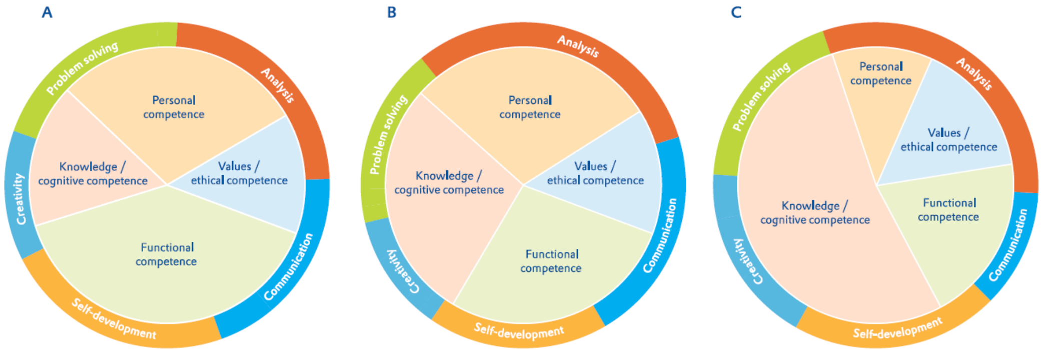

Fig. 1. Comparison of possible occupational competence mixes of different water professionals: **(a)** director of a catchment agency interacting with various stakeholders and managing various resources (human resources, finances, facilities and infrastructure etc.), **(b)** water engineering consultant who specialized on hydraulic structures, and **(c)** research water chemist specialist on processes related to transport of micro-pollutant.

HESSD
9, 2935–2957, 2012
Competency profile for water professionals

S. Uhlenbrook and E. de Jong

Title Page
Abstract | Introduction
Conclusions | References
Tables | Figures
◀I | ▶I
◀ | ▶
Back | Close
Full Screen / Esc
Printer-friendly Version
Interactive Discussion

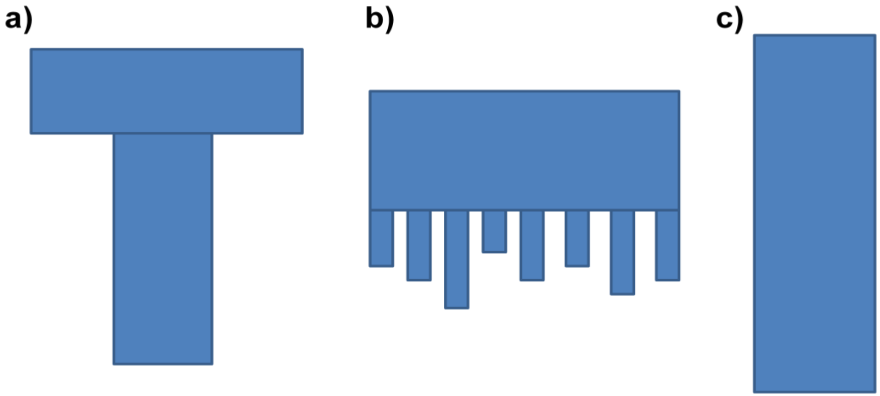

Fig. 2. Schematic sketch of the competency profiles of **(a)** T-shaped professionals, **(b)** generalists, and **(c)** I-shaped professionals (adapted from Oskam, 2009, modified).

HESSD
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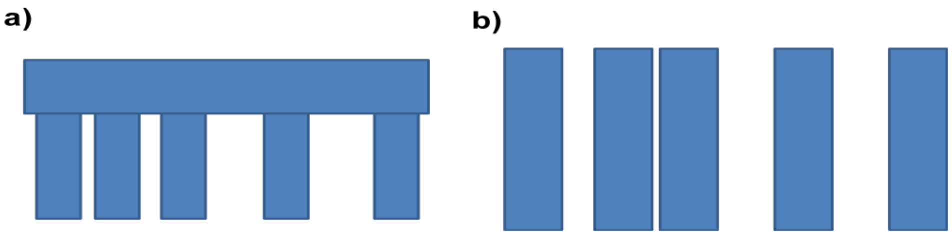

Fig. 3. Competencies profiles in interdisciplinary cooperation of **(a)** T-shaped professionals and **(b)** I-shaped professionals (adapted from Oskam, 2009, modified).

HESSD
9, 2935–2957, 2012

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