Learning and Cognition Programme

Design and Support for Learning and Expertise Development

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1. Management Summary

The Learning and Cognition Programme (L&C) at the Centre for Learning Sciences and Technologies (CELESTEC) at the Open Universiteit in the Netherlands will run for a five-year period from 2010 through 2014. It employs research, laboratories (following the principles of open innovation), and solutions activities with regard to flexible environments for the acquisition of complex cognitive skills, solving complex information problems and expertise development in the context of lifelong learning. This document presents a framework and sets boundaries for research projects, laboratories, and solutions within this Programme. With regard to research, the Programme is a successor of the Programmes Instructional Design for Open Tasks, Environments and Communities (ID-OTEC 2004-2008) and Instructional Design for Competency-based Learning in Post-Secondary Higher Education (1999-2003) which have achieved national and international recognition in the scientific community. The ID-OTEC Programme was ranked second of twenty research programmes in the national ‘research assessment pedagogy and education science 2002-2005’ (Quality Assurance Netherlands Universities), with highest scores for quality and viability. The strengths and weaknesses of both Programmes identified in the assessment of the research quality were used to develop this new Programme. In general, the new Programme builds on state-of-the-art knowledge in the field of educational psychology, educational science, and educational technology, maintaining its strong focus on use-inspired basic research to provide valuable output for both the practical field of education (e.g., practical guidelines, workshops, models, tools, and professional publications) and the international scientific community (e.g., publications in high-quality SSCI journals). In contrast to the former research Programme, this one has a stronger focus on lifelong learning. As a result, learner characteristics such as age and prior knowledge or expertise are emphasized and a focus on self-regulated learning skills (i.e., learning how to learn), are added. In addition, the new Programme is positioned within the Learning Sciences which emphasizes a multidisciplinary approach to not only to research, but also to explore, co-develop and test innovations in laboratory settings and to create sustainable and evidence-based solutions. Exploiting the knowledge gained through research and laboratory activities for the educational field will be an important activity within the new Programme (e.g. solutions). To ensure that applicable research outcomes will flow through into the educational field, clear structures, processes, and incentives are created. The change of focus from higher education to lifelong learning has broadened the Programme to new educational sectors and target groups, approaches new funding agencies, and explores new partnerships and exciting scientific developments.

The Programme has three themes, namely Flexible Environments for the Acquisition of Complex Cognitive Skills, Solving Complex Information Problems and Development of Domain-specific Expertise. Each theme has unique questions that are guided by the assumption that the ultimate goal of lifelong learning is to arrive at flexible learning, in which learners have constructed cognitive schemata that allow for transfer of skills, knowledge, and attitudes to a variety of settings, and sustainable learning, in which learners are responsible for regulating and maintaining their own further learning by making decisions that stimulate the construction of flexible cognitive schemata and transfer. Questions for Research, Laboratory and Solutions are guided by three goals: Sustainability, Flexibility, and Responsibility. The ultimate goal of design of lifelong learning is sustainable learning; learners or groups of learners can regulate and maintain their own learning such that they can shoulder at least part of the responsibility for creating their own learning environment based on arrangements of learning tasks and learning assessments, and that learners or groups of learners can use the knowledge, skills, and attitudes resulting from learning situations in a flexible way.
2. Introduction

This document presents a framework and sets boundaries for research projects, laboratories (following open innovation principles), and solutions that may be performed as part of the Learning and Cognition: Design and Support for Expertise Development Programme. With regard to research, the Programme is a successor of the Programmes Instructional Design for Open Tasks, Environments and Communities (ID-OTEC 2004-2008) and Instructional Design for Competency-based Learning in Post-Secondary Higher Education (1999-2003).

The ID-OTEC Research Programme received a very high assessment in the last review by the QANU (Quality Assurance Netherlands Universities) in 2008. The only critical remark concerned the potential threat that lies in the expectation that the ‘applied’ work can provide funding opportunities that may compromise the purely scientific research, which may also make it more difficult to attract the right kind of scholars to the institute (QANU, 2008, p.53). This concern has been taken into account in this programme plan by creating conditions that maintain the strong focus on ‘pure’ research as a basis for more ‘applied’ research activities.

The Programme, which is part of the Centre for Learning Sciences and Technologies (CElstec) formerly the Educational Technology Expertise Centre (OTEC) of the Open Universiteit in the Netherlands (Ounl), will run for a five-year period from 2010 through 2014. Within the Programme, research, laboratory, and solution activities with regard to the design and support of learning and expertise development are employed. Using a lifelong learning perspective, those activities will focus on the three main components of individual and group-based learning environments: learning tasks, learning environments, and learning assessments within the context of three research themes, namely flexible environments for the acquisition of complex cognitive skills, solving complex information problems and development of domain-specific expertise. Each theme has unique questions that are guided by the assumption that the ultimate goal of lifelong learning is to arrive at flexible learning, in which learners have constructed cognitive schemata that allow for transfer of skills, knowledge, and attitudes to a variety of settings, and sustainable learning, in which learners are responsible for regulating and maintaining their own further learning by making decisions that stimulate the construction of flexible cognitive schemata and transfer.

This document provides a general description of the Programme and its management and organisation issues.

3. Position of the Programme

The L&C Programme is one of the three programmes of CELSTEC. The activities that are employed within the Programme contribute to the mission and ambitions of the OU and of CELSTEC. The mission of the OU is to:

1. develop, provide and promote innovative higher distance education of top quality, in collaboration with networks and alliances;
2. be the prime university for lifelong learning by addressing the wide-ranging learning needs of people during their course of life, plus the need to achieve considerable increase of the knowledge level of the community at large;
3. play a pioneering role in open, higher distance education and display leadership in educational innovation, both in the Netherlands and internationally.
Furthermore, CELSTEC aims to study, develop and provide sustainable and evidence-based solutions for the advancement of learning at work, at school, at home and on the move. To reach this goal CELSTEC activities cover the following three basic functions:

1. Creation of new knowledge, technologies and services through Research;
2. Experimentation with new knowledge, technologies and services in pilots and trials (i.e., showcases and proofs of concept) through Laboratories;
3. Sharing and dissemination of new knowledge, technologies and services through Solutions.

The activities of CELSTEC are organised in three programmes and an institute for Training & Education, which use different perspectives to realise the mission and ambitions of CELSTEC and the OU. The L&C Programme takes a cognitive perspective by investigating the mechanisms that underlie learning and expertise development and by using this knowledge for the design and support of learning, transfer and expertise development. The Learning Media Programme takes the perspective of digital media, including interactive content development, representations, user behaviours, communication between users, awareness and usability. The Learning Networks Programme focuses on the networking characteristics and the self-organising behaviours of large populations of users. In addition, CELSTEC’s core expertise is disseminated by the Education and Training Institute, which hosts the governmentally accredited academic Master Programme Learning Sciences, and delivers training and workshops.

4. Mission

The mission of the L&C Programme is to promote lifelong learners and groups of learners to acquire skills, knowledge, and attitudes (i.e., competencies), to be able to transfer those competencies to a variety of settings and to plan, regulate and maintain their own further learning. This is realised by uncovering the cognitive processes underlying learning and using the resulting knowledge to develop a comprehensive theory of instructional design and develop and investigate guidelines to inform the design of effective and efficient learning tasks, learning environments, and learning assessments.

The Programme is positioned within the field of the learning sciences. This is, in itself, a broad field with several sub disciplines, which explicitly encourages a multidisciplinary or even transdisciplinary approach to the study of educational questions, by building on state-of-the-art knowledge in psychology, cognitive science, computer science, and neuroscience.

The programme has a strong focus on use-inspired basic research to provide valuable output for both the practical field of education (e.g., practical guidelines, workshops, models, tools, and professional publications) and the international scientific community (e.g., publications in high-quality SSCI journals, scientific workshops, participation in international scientific conferences).

5. Three Goals of the Programme

The research, open laboratories, and solutions questions and activities of the Programme are inspired by three overarching goals: sustainability, flexibility, and responsibility.

Sustainability

The key to surviving in an ever more rapidly changing and complex world with increased emphasis on web-based learning, remote learning, blended courses, and lifelong learning, is
Learning how to learn. Lifelong learning is “...all purposeful learning activity, undertaken on an ongoing basis with the aim of improving knowledge, skills and competence” (Commission of the European Communities, 2000, p. 3). Therefore, the ultimate goal of instructional design for lifelong learning is to arrive at sustainable learning, which means that learners have acquired such a level of expertise (i.e., knowledge skills, and attitudes) that they are able to regulate and maintain their own further learning. Effective self-regulated learning requires learners to make good study decisions resting on accurate monitoring of ongoing learning, a realistic model of how learning happens, and appropriate use of study strategies (Kornell & Bjork, 2007). Learners should make those decisions by trying to maximise long-term learning. A basic assumption of the research programme is that the ability to manage unsupervised learning effectively can be promoted by gradually decreasing control of the learning process by others (e.g., teacher/coach or eLearning application), going from almost exclusive control by others, via shared control by others and learners, to arrive at almost exclusive control by learners themselves, whilst supporting the learners’ acquisition of skills required for taking control.

In the context of the topical focus on lifelong learning, it is important to realise that people of all ages need to be prepared for sustainable learning. Age is a learner characteristic that is known to impact the functional structure of human memory. On the one hand, neuroscience research has shown that the prefrontal cortex of the brain, which plays a role in many executive functions (which presumably play an important role in self-regulation), continues to mature into young adulthood. This poses the question of how students in primary and secondary education can best be prepared for lifelong learning (i.e., can they be taught to self-regulate their learning behaviour and if so, how?). On the other hand, one of the central findings of cognitive aging research is that the efficiency of cognitive operations declines with age in adults, and that these are most likely to emerge in complex cognitive tasks requiring effortful processing (e.g., Paas, Camp, & Rikers, 2001; Perfect & Maylor, 2000). However, it is important to realise that higher levels of expertise are associated with more evolved and complex schemas, which on the one hand might ease load while on the other hand need to be accommodated due to updated and upgraded new knowledge. In other words, the effects of aging may primarily show in learning novel tasks or information, and less when older individuals can build on their expertise and are able to compensate for their cognitive declines.

Flexibility

Another consequence of learning in a rapidly changing and complex world is that learners need to be prepared for flexible adaptation to new problems and settings (i.e., transfer). When learning complex cognitive tasks, learners usually need to use the acquired knowledge, skills, and attitudes in a flexible way after the learning phase. The goal of instructional design is to optimise learning arrangements to stimulate this flexible use of acquired knowledge and skills (i.e., transfer).

Within fixed learning arrangements, several measures can be taken to stimulate transfer. For example, scheduling learning tasks not in blocks (e.g. AAA-BBB-CCC) but randomly (e.g., A-C-B-C-A-B-B-A-C) enhances the development of flexible cognitive schemata (De Croock, Van Merriënboer, & Paas, 1998; Schmidt & Bjork, 1992). In addition, initially providing a high amount of support that allows learners to build cognitive schemata and then gradually requiring the learner to become more active by reducing support, is known to be effective for transfer (Renkl & Atkinson, 2003; Van Merriënboer; Kirschner, & Kester, 2003), as it takes into account the increasing expertise of the learner.

However, ideally, flexibility of cognitive schemata can be fostered by dynamically adapting the succession of authentic learning tasks to individual student needs (sensitivity). In an adaptive curriculum, not all learners receive the same sequence of learning tasks (i.e., one educational programme for all), but each learner receives his or her own sequence of learning tasks that is - dynamically - adapted to his or her individual needs, progress, and
preferences. Research suggests that adaptive training is more efficient and leads to better transfer performance (e.g., Corbalán, 2008; Corbalán, Kester, & Van Merriënboer, 2006; Kalyuga, 2006, 2008; Kalyuga & Sweller, 2004, 2005; Salden, 2005)

**Responsibility**

The sensitivity of the learning environment to the individual needs, progress, and preferences is critical to the selection of a subsequent learning task and can enable the transfer of knowledge and skills. At one extreme, it is the system (e.g., teacher, eLearning application) that needs to be sensitive to a learner’s progress to select the next, most suitable learning task that the learner should work on. At the other extreme, it is the self-regulated learner who needs to be sensitive to his or her progress and selects a subsequent learning task from all available tasks. But as a rule, learning task selection will be a shared responsibility of the system and the learners together, where the responsibility of the learners may increase as they further develop the self-regulation skills necessary to select suitable learning tasks, including not only self-assessment skills but also orienting skills (What could I learn from this task?), planning skills (How much time and effort would I need to invest in this task?), and monitoring skills (Did I learn enough to stop working on this task?).

**6. Relevance of the Programme**

The Programme takes a multidisciplinary perspective on learning. Along with education/educational science, its contributing fields include psychology, cognitive science, computer science, and neuroscience. This is done by taking into account the findings from those fields and/or adopting the methodologies and techniques used in those fields, as well as by forming cross-disciplinary partnerships (cf. the NWO-PROO funded interlinked research project on ‘Fostering self-monitoring and self-regulation in primary and secondary education’, 2009-2013). The Programme also strives to be relevant for both the practical field of (higher) education and the scientific field of educational design and development. Current changes in the field of education are closely related to societal and technological developments. First, many traditional tasks have been taken over by machines. What remains are competencies that require the application of complex skills, flexible problem solving abilities, higher-order skills, interpersonal skills, and particular attitudes and values. Second, Information and Communication Technologies (ICTs) heavily influence delivery systems used for training and instruction and thus, learning. Asynchronous distributed e-learning environments, competency-based multimedia practicals and virtual reality simulation environments are good examples. These societal and technological developments have direct repercussions for the field of education. In particular, increasing numbers of curricula are based on rich learning tasks, which are assumed to be critical for the development of professional competencies. Furthermore, heavy ICT use (e.g., e-learning) may increase the adaptivity of education to learners’ needs (Schellekens, Paas, & Van Merriënboer, 2003) and, under particular circumstances, also have an added pedagogical value compared to traditional instructional methods (see Jochems, Van Merriënboer, & Koper, 2004).

The Programme assumes that successful implementation of those developments in the educational field requires extension of existing theories and probably the development of new theories. The general assumption of recent instructional theories is that providing learners with authentic ‘whole’ tasks (1) helps them to integrate the knowledge, skills, and attitudes necessary for effective task performance, (2) gives them the opportunity to learn to coordinate qualitatively different constituent skills that make up this performance, and (3) enables them to transfer what is learned to their daily life or work settings. However, these
complex tasks pose such high loads on learners’ cognitive systems that it may interfere with efficient learning if instructional design is not well-aligned with cognitive architecture. Based on analyses of cognitive processes, the Programme focuses on determining how learning tasks, environments and assessments can be optimally aligned with the cognitive architecture, and what role ICT can play in their design.

The Open Universiteit in the Netherlands
The Programme will contribute to the realisation of the goals of the mission and strategy of OU NL and CELSTEC, as described in the most recent ‘Instellingsplan’ (University Strategic Plan), and ‘Otec Nieuwe Stijl’ (The New OTEC), and the new educational concept of the OU as described in “De Student Centraal” (OU, 2007; The Student at the Centre). In addition, the Programme will take account of and contribute to the lifelong learning services within the OU, IPO (Instellingsbreed Programma Onderwijsinnovatie; University Wide Programme for Educational Innovation) services, and the research programme of the OU’s Netherlands Laboratory for Lifelong Learning (NeLLL).

Education
The Programme will also contribute to the innovation of Dutch education and of the Open Universiteit through IPO. Like the OU, many educational institutes are making the switch to approaches that focus on whole learning tasks such as competency-based learning, but also project-based education, the case method, and problem-based learning. In addition, they aim at enrichment of their curricula with new technologies, yielding combinations of traditional teaching with e-learning in “blended learning” approaches. One of the main problems that educational institutes encounter in their reorientation is related to deciding what an optimal solution for their needs would be and implementing the necessary changes. The proposed Programme will develop practical guidelines and tools that may help to do so.

The Scientific Community
The Programme will contribute to state-of-the-art theoretical advancements in the field of L&C. In the previous programmes major theoretical advancements have been made with regard to the instructional design for expertise development in complex cognitive tasks, multimedia learning and assessment. The new Programme will build on those theories and use this knowledge to design learning tasks, environments, and assessments that stimulate individual or groups of learners to regulate and sustain their own learning.

7. Theoretical Contributions
Instructional design can be seen as a process or activity, referring to the systematic and cost-effective development of instructional materials using instructional theory to ensure the quality of those materials (Seels & Glasgow, 1997). But instructional design is also a science. This field of research aims at the creation of detailed specifications for the development, implementation, evaluation, and maintenance of tasks, environments and assessments that facilitate learning. Instructional design theories and models are coherent sets of such specifications, where the specifications are typically based on learning theory and cognitive psychology and take the form of instructional methods. This Programme will continue to work on already existing design theories for complex learning, multimedia learning, self-regulated learning and collaborative learning, though alternative and/or complementary design theories will also result from this new Programme.
Four Component Instructional Design Theory

A relevant theory for the design of learning tasks and environments is provided by the four-component instructional design model (4C-ID-model; Van Merriënboer, 1997; for an updated version see Van Merriënboer & Kirschner, 2007; for the software version, see De Croock, Paas, Schlanbusch, & Van Merriënboer, 2002). This model provides guidelines for the (1) specification, (2) development, and (3) sequencing of learning tasks. With regard to the specification of learning tasks, the model provides several approaches for analysing learning domains in mental models, which describe the regularities in a domain, and cognitive strategies, which describe useful approaches to solving problems in a domain. With regard to the development of learning tasks, the model distinguishes several kinds of learning tasks, such as case studies or worked-out examples, reverse tasks, completion tasks, goal-free tasks and so forth which fulfil different functions in the educational process. With regard to the sequencing of learning tasks, the model provides a number of 'whole-task approaches', which all try to confront the learner with whole, realistic tasks as early as possible in the educational process. Task classes are used to sequence learning tasks from simple to complex. The first task class refers to the simplest kind of tasks that professionals encounter in the real world, and subsequent task classes smoothly increase the level of complexity.

The 4C-ID-model is formulated as a rather general instructional theory. New research projects could aim at the further specification of the model in order to tailor it to particular learning domains or to the use of specific media. For instance, there has been a first attempt to develop a media-specific version of the model for e-learning and blended learning (Van Merriënboer, Bastiaens, & Hoogveld, 2003). Second, research is focusing on different types of learning tasks that provide more or less support to learners. Alternatively, new approaches to support and guide learners during their task performance could be developed and tested – including approaches for motivational support. Finally, the model provides a preliminary framework for the development of assessments and adaptive approaches to instruction. For the learning tasks in one and the same task class, a substantial amount of guidance and support is typically provided for earlier tasks, but no guidance and support is provided for later tasks. In this way, the final learning tasks in a task class can well be used as assessment tasks. If the performance on these tasks meets all standards and criteria, the learner is ready to proceed to the next task class – an adaptive process that can be described in terms of dynamic learning task selection.

Design Theory for Multimedia Learning

Theories for multimedia learning identify multimedia principles and provide guidelines for devising multimedia messages consisting of, for instance, written text and pictures, spoken text and animations, or explanatory video with a mix of moving images with spoken and written text. Examples of such theories are Mayer’s cognitive theory of multimedia learning (Mayer, 2005) and Sweller’s Cognitive Load Theory (CLT; for overviews see; Paas, Renkl, & Sweller, 2003; Sweller, Van Merriënboer, & Paas, 1998; Van Merriënboer & Sweller, 2005).

CLT is one of the most important pillars of the L&C Programme because it directly addresses the issue of aligning instruction and human cognitive architecture. According to CLT, this architecture consists of a working memory limited in capacity and duration, with partly independent processing units for visual and auditory information, which interacts with an unlimited long-term memory. CLT is concerned with the development of instructional methods that efficiently deal with the limitations and potentials of working memory and long-term memory in order to stimulate meaningful learning. The theory distinguishes three types of cognitive load. Intrinsic cognitive load is the direct result of the amount of element interactivity in learning materials; extraneous cognitive load is related to irrelevant cognitive processing and interferes with learning, and germane cognitive load is related to learning processes such as schema construction and automation. The general guideline from CLT is to
decrease extraneous cognitive load and to optimise germane cognitive load – within the limits of total available cognitive capacity. CLT has yielded many principles for the design of multimedia learning environments, such as the modality effect (Tabbers, 2002), the just-in-time effect (Kester, 2003), the split-attention effect, and many others (for an overview, see Mayer & Moreno, 2003).

Until now, CLT has been able to generate effective instructional methods for relatively simple procedural and conceptual tasks (i.e., simple from an objective perspective, from a subjective perspective, such tasks may be called complex, e.g., for novice learners). However, there is a clear need to extend the research focus to:

- designing instruction for complex learning tasks and multimedia learning environments at different levels of learners’ expertise – including lifelong learners and elderly learners (see Paas, Camp, & Rikers, 2001; Van Gerven, 2002).
- methods that not only reduce extraneous cognitive load but also those which yield germane cognitive load, such as variability of practice, questions that evoke deep processing, and epistemic games (Van Merriënboer, Schuurman, de Croock, & Paas, 2002).
- motivation, since for any instructional design to be effective, learners should be motivated or willing to invest mental effort in it (Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Paas, Tuovinen, Van Merriënboer, & Darabi, 2005). This is especially the case for methods that yield germane load, which do lead to improvements in performance, but also require effortful processing. If learners are not motivated to improve their performance and/or to invest the effort, these methods will not have much effect (cf. the difference between ‘practice’ and ‘deliberate practice’; Ericsson, 2002). Malone and Lepper (1987), for example, provide a list of factors that may promote intrinsic motivation for learning, and other motivational theories such as Ryan and Deci’s (2000) Self-Determination Theory and more specifically their Cognitive Evaluation Theory (Deci & Ryan, 1985) can be used to further identify the characteristics that promote or hinder motivation.

Finally, CLT may offer another perspective on assessment and task selection. Clearly, the same level of performance can be assessed differently depending on the amount of mental effort that is necessary for reaching it. Salden, Paas, and Van Merriënboer (2006a, b) claim, for instance, that the best new learning task for a person who is reaching a high level of performance with a very low investment of mental effort will be different from the best new learning task for a person who is reaching the same level of performance with a very high investment of mental effort. The first person will be advised to work on a learning task that is more difficult than the task for the second person.

**Design Theory for Self-Regulated Learning**

Active, self-regulated learning has beneficial effects on learning outcomes (Boekaerts, 1997; Zimmermann, 2002). Effective self-regulated learning requires learners to make good study decisions resting on accurate monitoring of ongoing learning, a realistic model of how learning happens, and appropriate use of study strategies (Kornell & Bjork, 2007). Learners should make those decisions by trying to maximise long-term learning.

Among others, Koriat (1997) has shown that learners are relatively insensitive to factors of the learning environment that can enhance long-term learning and transfer performance. For example, when low-expertise learners are confronted with a problem solving task, they do not have a good impression of what there is to know about a particular problem (Ormrod, 2004) and therefore cannot determine which information might help them to solve it. The decisions those learners make on what information to use can result in misconceptions, especially when dealing with more complex problems or tasks (Hannafin, Land & Oliver, 1999). In addition, it has been found that properly perceiving the problem
demands is often problematic for novices (see Broekkamp, Van Hout-Wolters, Van den Bergh, & Rijlaarsdam, 2004 and Broekkamp, Van Hout-Wolters, Rijlaarsdam, & Van den Bergh, 2002 for task demands in relation to test expectations; Luyten, Lowyck, & Tuerlinckx, 2001 for task perception; and Zumbach & Reimann, 2001 for goal orientation). This impedes novices in acting upon their information requirements. So, in the context of self-regulated learning, learners need to become sensitive to the factors or conditions of learning that can enhance long-term retention and transfer. Obtaining a better understanding of the meta-memory processes involved in learners’ becoming aware of the differential memorial consequences of factors of the learning environment that can enhance long-term learning and transfer, seems a fruitful avenue of research. A basic assumption of the research programme is that the ability to manage unsupervised learning effectively can be promoted by gradually decreasing control of the learning process by others (e.g., teacher/coach or eLearning application), going from almost exclusive control by others, via shared control by others and learners, to arrive at almost exclusive control by learners themselves, whilst supporting the learners’ acquisition of skills required for taking control.

Design Theory for Collaborative Learning

Groups of collaborating learners can be considered as information processing systems consisting of multiple working memories (WM). Consequently, it can be argued that groups have effectively more processing capacity available than an individual with one WM. In a group, the cognitive load can be shared among group members enabling them to deal with more complex problems than individuals. Although the cognitive load caused by communication and coordination within the group, the so-called transaction costs, have to be taken into account, in case of complex cognitive tasks these costs are minimal compared to the advantage of being able to share the high cognitive load among group members. This distribution advantage was recently proposed by F. Kirschner, Paas, and P. A. Kirschner (2009a) and confirmed in a recent experiment of the same authors (F. Kirschner, Paas, & P. A. Kirschner, 2009b) comparing the effects of group and individual learning of complex cognitive tasks on transfer efficiency. By making use of each other’s processing capacity through sharing of cognitive load imposed by a task, it was possible for group members to more deeply process information elements, and construct higher quality schemata in their long-term memory than learners working individually. Another situation occurs with low complexity tasks in which a learner has sufficient capacity to solve the problem individually. In that case, solving the problem in collaboration, in terms of experienced cognitive load, does not have an advantage for the group member or could even be disadvantageous, because of the relatively high load caused by the transaction costs within the group.

Towards Integrated Design Theories

Instructional design is pre-eminently a multidisciplinary field. Many theories, from research fields (e.g., cognitive science, computer science, psychology, education, neuroscience, or social science), yield valuable input for the further development of instructional design theory. It is impossible to describe all specific theories that may be helpful because this list is too extensive. But broadly speaking it should be clear that, for instance, theories in the field of self-regulation, student motivation, and student perceptions have important implications for the further development of instructional design theory (see, e.g., Könings, Brand-Gruwel, & Van Merriënboer, 2008; Prins, 2002). Three levels of research can be distinguished, and the Programme allows for projects at all three levels. At the first level, hypotheses about the effectiveness of particular instructional methods are derived from relevant theories and tested in instructional settings. At the second level, instructional design models are formulated as coherent, interrelated sets of tested instructional methods. This may either be realised by formulating a “new” instructional design model (e.g., an ID-model for the
development of performance assessments) or by incorporating new insights into an already existing ID-model (e.g., including guidelines for the development of performance assessments in the 4C-ID-model; see Straetmans, Sluijsmans, Bolhuis, & Van Merriënboer, 2003). At the third level, instructional design models are combined into more powerful, comprehensive models. For instance, there have been some first attempts to integrate the 4C-ID-model with Cognitive Load Theory (Van Merriënboer, Kirschner, & Kester, 2003).

8. Research Line

The mission of the research line of the L&C Programme is to promote formal, lifelong, individual and group learning (i.e., expertise development) in complex cognitive domains through uncovering the underlying cognitive processes and the development of a detailed and comprehensive theory of instructional design. Firstly, this is realised by research into guidelines for the design of learning tasks, learning environments, and learning assessments that stimulate learners to acquire and integrate the knowledge, skills, and attitudes that underlie effective task performance, while taking into account the limitations of working memory and individual differences such as current level of expertise. This will help learners construct a knowledge base that allows for transfer of what is learned to new problems in unfamiliar situations. Secondly, the research will focus on instructional design for the development of self-regulated learning skills by creating learning experiences in which learners are stimulated to gradually take control over their own learning (Van den Boom, Paas, & Van Merriënboer, 2007).

Recent instructional theories tend to focus on authentic learning tasks that are based on complex real-life experiences as the driving force for learning (Merrill, 2002; Van Merriënboer & Kirschner, 2007). The general assumption of these theories is that providing learners with authentic ‘whole’ tasks (1) helps them to integrate the knowledge, skills, and attitudes necessary for effective task performance, (2) gives them the opportunity to learn to coordinate qualitatively different constituent skills that make up this performance, and eventually (3) enables them to transfer what is learned to their daily life or work settings. In addition, to facilitate such transfer, and to ensure that learners also continue to further develop and sustain their expertise (lifelong learning), they are required to develop self-regulated learning skills. Therefore, fostering these skills is another major aim of contemporary educational programmes.

Three Themes of the Research Line

The L&C Programme contains three themes.

Theme 1: Creating Flexible Environments for Acquiring Complex Cognitive Skills

Flexible learning environments - not necessarily computer-based - follow learners during the learning process and monitor their progress in the acquisition of complex cognitive skills in order to adapt the learning content or instruction to their current needs. Research shows that such environments facilitate learning. This theme focuses on the following aspects of these environments: (1) prior knowledge activation, (2) learning tasks, (3) assessments/tests and (4) the adaptation loop. For each of these aspects research topics are identified. The first topic focuses on choosing prior knowledge activation strategies (e.g., mobilising, perspective taking or self-explaining) as a function of knowledge and/or skill level to enhance complex cognitive skill acquisition. The second topic focuses on choosing learning content (i.e., assignments/problems and information in single, multi or hypermedia format) and/or instruction (e.g., support, guidance, feedback, or learner control) as a function of knowledge and/or skill level to facilitate complex cognitive skill acquisition. The third focuses on using assessments and tests as learning instruments. The fourth and final topic focuses
on (automatically) diagnosing assessment/test products, (automatically) determining the instructional consequences and, the role of learner control during these processes.

**Flexible learning environments**

Flexible learning environments follow learners during the learning process and monitor their knowledge and/or skills progress in order to adapt the learning content or instruction to their current needs. Research shows that flexible learning environments facilitate learning (e.g., Corbalán, Kester, & Van Merriënboer, 2006). Modern technologies make mass customization in education possible and although flexible environments do not necessarily have to be computer-based, these technological advances caused a renewed interest in these systems.

Here, flexible learning environments consist of four elements: (1) prior knowledge activation, (2) learning tasks, (3) tests and (4) the adaptation loop (see Figure 1).

![Figure 1. A flexible learning environment](image)

In the following sections, each element of this system is described briefly.

**Prior knowledge activation**

Many studies have shown that prior knowledge activation facilitates subsequent information processing and recall (for an overview see Machiels-Bongaerts, Schmidt, & Boshuizen, 1995). Prior knowledge activation enables learners to incorporate new information in already existing cognitive schemata and so, facilitates elaboration (De Grave, Boshuizen, & Schmidt, 1996; De Grave, Schmidt, & Boshuizen, 2001; Schmidt, de Volder, & de Grave, 1989). Research on prior-knowledge-activation strategies in individual learning focuses on mobilisation or brainstorming (e.g., Peeck, 1982; Machiels-Bongaerts, 1993), perspective taking (e.g., Pichert & Anderson, 1977), and self-explanation (Chi, 2000). Mobilisation implies that learners are asked to generate as many relevant concepts (Machiels-Bongaerts, Schmidt, & Boshuizen, 1993; 1995) or potential problem solutions (De Grave et al. 1996; 2001) as possible, before information processing or problem solving. Perspective taking signifies that learners are asked to approach the tasks from a specific perspective before information processing or problem solving, for example, learners are required to learn a text about ECC Fishery policy from the perspective of a tour operator (Machiels-Bongaerts et al., 1995). During self-explanation, learners generate explanations of the learning material in their own words (Chi, de Leeuw, Chiu & LaVancher, 1994).
**Research focus:** Choosing prior knowledge activation strategies as a function of knowledge and/or skill level.

**Learning tasks**

**Learning content.** Learning tasks contain an assignment or a problem and offer information which can be minimal or substantial to help learners carry out the assignment or solve the problem. They aim at the acquisition and the transfer of complex cognitive skills. Complex cognitive skills involve knowledge and cognitive skills. The mastery and combined action of these elements determine the mastery of the whole complex cognitive skill. Examples: diagnosing patients, teaching, software development, troubleshooting complex systems etcetera. Learning tasks can be presented in a single-medium, multimedia or hypermedia format (e.g., Kester, 2003; Van Merriënboer, 1997; Van Merriënboer & Kirschner, 2007).

**Instruction.** Common instructional interventions that can be part of tasks are support, guidance, feedback and learner control. The term 'support' is reserved for interventions that aim at decreasing irrelevant cognitive load during performing learning tasks. These types of interventions can be very diverse, for example presenting well-designed worked examples or completion tasks instead of conventional problem-solving tasks (e.g., Paas, 1992), presenting multimodal instruction (e.g., Moreno & Mayer, 1999), self-pacing in animations (e.g., Mayer & Chandler, 2001), signalling or cueing (e.g., Jeung, Chandler, & Sweller, 1997) or presenting graphic organizers (e.g., Potelle & Rouet, 2003).

The term 'guidance' is reserved for interventions that aim at increasing relevant cognitive load while working on learning tasks. Examples of guidance are providing hints (e.g., Paas, Camp, & Rikers, 2001) or prompts (e.g., Renkl, Stark, Gruber, & Mandl, 1998 (self-explanation prompts) or Van den Boom, Paas, Van Merriënboer, & Van Gog, 2004 (reflection prompts)).

Feedback can be used to improve performance, transfer and reflection (e.g., Ross & Morrison, 1993; Butler & Winne, 1995). A distinction is made between corrective feedback which is specific and helps learners recognize the errors they made during performance and cognitive feedback which is general and helps learners to reach a diagnosis of possible causes of suboptimal performance. Providing students with learner control facilitates perseverance and improves motivation (Reeve, Hamm, & Nix, 2003). Researchers hold that as knowledge and skill levels increase through experience, system control should be decreased and learner control should be increased. Several studies showed that low prior knowledge learners or domain novices lack adequate domain knowledge and skills to judge and thus control their own learning which predisposes them to make ineffective instructional decisions (see Niemiec, Sikorski, & Walberg, 1996 for a review). So, although learner control has beneficial effects on perseverance and motivation, it does have equivocal effects on learning and learning outcomes. In general, Merrill (1975) suggested that learner control enables learners to learn how to learn and how to adapt to new and unfamiliar educational situations but this is not unambiguously confirmed in research.

**Research focus:** Choosing learning content, instruction, and/or amount of learner control as a function of knowledge and/or skill level.

**Tests**

Although educational practice makes more and more use of authentic assessments (Guilikers, Bastiaens, Kirschner, & Kester, 2006) or transfer tasks (Salomon & Perkins, 1989) in which a student has to show her competence (i.e., the combination of knowledge, skills and attitude), tests (e.g., multiple-choice questions or short-answer questions) are still widely used to measure knowledge (Segers, Dochy, & De Corte, 1999). In addition, educational psychologists use cognitive tests to acquire more insight in an individual's knowledge. These tests are also used to track students' learning processes, compare their knowledge to that of an instructional agent (i.e., teachers, instructors, subject matter), or to support learning or predict achievement (Jonassen, Beissner, & Yacci, 1993). Two types of
cognitive test methods can be distinguished: verbal and graphical. These methods allegedly
tap the same knowledge but differ in their emphasis: whereas verbal methods yield a
summary of a person’s interpretation of specific information, graphical methods yield a
structural representation (Pearson & Fielding, 1991). All these test forms can be part of a
flexible learning environment.

The testing effect is thoroughly studied in the verbal learning tradition and signifies that
tests - as compared to restudy episodes - significantly improve learner’s memory for
wordlists on the long term (for an enumeration see Roediger & Karpicke, 2006). Increasingly
more attempts have been made to investigate the testing effect under educationally
relevant conditions with materials that are more complex in content than wordlists (e.g.,
Chan, McDermott & Roediger, 2006; McDaniel, Roediger & McDermott, 2007). This is a
promising avenue for research because testing seems to be an efficient way to consolidate
knowledge and can easily be applied in educational settings.

Research focus: Using tests as learning instruments.

Adaptation loop
In the adaptation loop, the learners' test products are evaluated or contrasted to an expert's
product in order to diagnose the learners' knowledge and/or skill level. Based on this
diagnose it is decided what learning content is presented and/or which instructional
interventions are applied next. Besides the test products measures as invested mental effort
(e.g., Corbalán et al., 2006, Salden, Paas, & Van Merriënboer, 2006a), accuracy (e.g., Salden,
Paas, & Van Merriënboer, 2006b), individual differences in, for example, ability (Snow, 1992;
Snow, & Swanson, 1992) can also play a role in diagnosing a learner's knowledge and/or skill
level and determining the instructional consequences.

Since different kinds of test methods can be used in flexible learning environments, the
test products that result from these tests are very different as well. This has important
consequences for real-time adaptation. Whereas multiple-choice questions, for instance,
yield very straightforward test products that can automatically be analysed, authentic
assessments and cognitive assessments do not. Sophisticated scoring rubrics are needed to
automatically analyse the former while sophisticated statistical analysis methods such as
Latent Semantic Analysis are needed to automatically analyse the latter products.

Research focus: (Automatically) Diagnosing test products, (automatically) determining the
instructional consequences and the role of learner control during these processes.

Theme 2: Solving Complex Information Problems
This theme deals with research on the processes that take place when students solve
information-based problems c.q. carry out different types of information-based tasks as well
as on instructional support within the learning environment to foster acquisition of
information problem solving – IPS - skills (e.g., information literacy). The research questions
that are characteristic for this research theme relate to uncovering the strategies and
processes that students employ when learning from multiple hypertext documents, how
students judge the trustworthiness of information and sources that they find on the
Internet, and how they integrate information from different sources to construct knowledge.
Finally, research on innovative ways of assessing IPS is carried out. Tools for providing
instructional support to foster the acquisition of IPS skills (e.g., process worksheets) will be
designed, developed and their effects will be studied.

Aim
In contemporary education emphasis is on meaningful learning, knowledge construction and
self-directed learning (Kicken, Brand-Gruwel, & Van Merriënboer, 2009; Loyens, Magda, &
Rikers, 2008). To stimulate students to construct knowledge in a meaningful way, students
receive learning tasks and assignments that require them to identify information needs,
locate information sources, extract and organize information from each source, and
synthesize information from a variety of sources. This set of activities is frequently defined as Information Problem Solving (IPS) (Eisenberg & Berkowitz, 1990; Brand-Gruwel, Wopereis, & Vermetten, 2005; Moore, 1995; Wolf, Brush, & Saye, 2003). IPS is a concept that combines the skills needed to access and use information, whether or not found on the World Wide Web (WWW). In other words, an information-based problem is a problem which requires information to solve it.

Research shows that many students are not able to solve information-based problems successfully. Research of Bilal (2000), Large and Beheshti (2000), MaKinster, Beghetto, and Plucker (2002), Wallace, Kupperman, Krajcik, and Soloway (2000) for instance, reveal that young children, teenagers, and adults do not always know which search terms to use when searching the WWW for information. Moreover, people of all ages do not always open websites based on a valid judgement of the results. The source is not always questioned and the choice for opening a site is highly guided by the title or summary of the site. Furthermore, research of Brand-Gruwel et al. (2005), Branch (2001), and Lazonder (2000) reveal that students lack regulatory skills and have difficulties defining the problem. Taking these research results into account, it can be concluded that students must learn to solve information-based problems and must learn transferable strategies.

Guidelines for designing IPS-instruction are therefore needed. A first step in designing IPS-instruction and the formulation of instructional design guidelines is a decomposition of the IPS-skill. Because the skill of IPS can be characterised as a complex cognitive skills the designer of instruction must be aware of the nature of skill acquisition, the heterogeneity of the constituent skills involved and the underlying learning processes. This means that unravelling the mental models representation the knowledge underlying the performance of the skill and the cognitive strategies involved when completing tasks are essential. Decomposition provides this insight in the cognitive strategies and mental models involved. Insights in the cognitive processes are the input for developing a systematic problem approach. Furthermore, knowing the cognitive strategies and skills involved the mental models needed to carry out the skills can be defined (Van Merriënboer, 1997). The aim of this research line is to unravel the processes involved in IPS and to study effects of instructional support to foster students’ IPS-skills and task performance. Before going into the research focus first a short elaboration will be provided concerning the IPS-process.

The IPS-process

Research conducted in the two previous (OTEC) research programmes led to a model that describes the skills needed for solving an information problem when the Internet is used for searching information. Figure 2 on the next page presents this model. The five constituent skills ‘Define information problem’, ‘Search information’, ‘Scan information’, ‘Process information’, and ‘Organize and present information’ are the main skills, which are, in turn, composed of underlying skills. Regulation occurs during the execution of all skills and positions on the top of the model.

The constituent skill Define information problem will always be performed at the beginning of the process. This skill is important in order to get a clear insight into the problem (e.g., Hill, 1999; Land & Greene, 2000; Moore, 1995). Without a good problem definition, the problem becomes hard to solve and answers may not be adequate. While defining the problem the main question and sub questions are formulated, requirements are taken into account, and prior knowledge on the subject matter must be activated.

When performing the skill Search information one has to select a search strategy, specify search terms, and judge the websites given in a 'hit list'. There are several search strategies that can be used while searching information on the WWW. The three most common used strategies are (a) using a search engine, (b) typing an address (URL) in the browser and (c) browsing by following links (Lazonder, 2000). When using the first strategy, an important sub skill is specifying the search term(s). Furthermore, the results in a hitlist
have to be judged on quality, relevance, and reliability (Wopereis, Brand-Gruwel, & Vermetten, 2008).

The site that is opened after a search will be scanned (Scan information) to get an idea of the kind of information, and if it is useful. While scanning one can elaborate on the content and combine the information with previous knowledge or other information found. When information is useful, it can be stored by using bookmarks or by copying and pasting information in a Word-file.

**Figure 2. Decomposition of the information problem solving skill**

As opposed to scanning information, the constituent skill Process information involves deep processing. The goal is to reach a deep understanding of the information (Schmeck & Geisler-Brenstein, 1989), and to reach an integration of the different pieces of information found and relevant prior knowledge (Wopereis et al., 2008). Elaboration is an important aspect and can be expressed by analysing, selecting, and structuring information. Especially for selecting information, criteria for judging the usefulness and quality of information are important.

The first four skills are part of the analysis phase. Organize and present information is part of the process that can be described as the synthesis. All the information will be combined and the information problem can be solved. Making the product as required in the task is the goal or outcome of this constituent skill. During this organizing and presenting of information elaboration remains important (Wopereis et al., 2008).

Regulation activities are carried out during the entire IPS-process. Especially, with the WWW as an extensive source of information, a strong demand is made on a persons’ regulation ability. Regulatory aspects such as orientation, monitoring, steering, and evaluation, play a key role in the execution of the skill (Brand-Gruwel, et al., 2005; Hill, 1999). The students need to articulate a plan for how to solve the information problem.
During the process they have to monitor, steer, and check if the proposed plan is still the right one, or decide if changes in the approach are needed. The efficiency and effectiveness of the process correlate with the quality of the regulation activities (Hill, 1999; Hill & Hannafin, 1997; Land & Greene, 2000; Marchionini, 1995; Tu, Shih, & Tsai, 2008). Moreover, the efficient use of regulation activities can compensate for a lack of domain knowledge (Moore, 1995; Land & Greene, 2000).

Research Focus

Research conducted in the past focused primarily on the whole IPS-process. Through expert-novice studies in which the participants solved IPS-problems while thinking aloud the processes were unravelled and the skills were decomposed (Brand-Gruwel, et al., 2005). Furthermore, effects of instructional support, using process work sheets, was determined to foster students' IPS process (Brand-Gruwel & Wopereis, 2006; Wopereis, et al., 2008).

After this initial phase, research focused on parts of the IPS process. Walraven, Brand-Gruwel, and Boshuizen (2008; 2010) addressed the process of judging information and their sources while searching, scanning and processing information found on the Internet. It also focused on how through instruction this skill could be fostered and transfer of the skill could be established. Brand-Gruwel, Van Meeuwen and Van Gog (2009) studied the criteria people use when judging information and sources. In this study, domain experts and novices (first year psychology students and their university teachers) solved information-based problems while their eye-movements were tracked. The impact of prior domain-knowledge is studied on the way one is judging.

Research projects being carried out at the moment this programme was written concern (1) processes carried out when organizing found information on the Internet and how this process can be supported by using social bookmarking tools to facilitate knowledge construction, (2) processes carried out when processing hypertext information and how students construct knowledge by making representations of texts, and (3) how students can be supported in presenting information in a written text by using outline tools present in word-processing programmes.

To get more insight in the cognitive processes involved of organizing information and processing hypertext, these projects involve using new research methods. In the past thinking aloud methods were the primary methods used to study these processes. Recent research (Van Gog, Paas, Van Merriënboer & Witte, 2005) has shown that using the cued retrospective report method with recorded eye-movements as cue results in a better capture of cognitive processes. Using this technique will give us more insight in the involved cognitive processes. Furthermore this gaze-tracking data will allow us to get a better ‘grip’ on how people search the Internet for information.

Furthermore, projects addressing the design of instruction to foster the IPS-processes will adopt the principles of the most recent instructional design models (Van Merriënboer & Kirschner (2007)). Promoting and stimulating the use of IPS means fostering the use of higher-order skills. In contrast to lower-order skills which focus primarily on knowledge, comprehension and/or application, higher-order skills refer to strategic knowledge and skills related to how to think well, such as widely applicable strategies for problem solving and meta-cognitive activities (Perkins & Salomon, 1989). There are various standpoints about how instruction should be designed to enhance students’ higher-order skills. Some argue that higher-order skills can be learned in specially designed courses, because the skills are the same across disciplines (e.g. Ennis, 1989; Paul, 1992). Others, such as McPeck (1981), state that generalisable thinking skills do not exist, and thus critical-thinking skills cannot be learned in isolation from a subject or knowledge-domain. In this line of thinking, Brown (1997) states that higher-order skills must be taught in the context of a specific subject matter in such a way that transfer to other domains is possible. Brown points out the importance of using real-life problems, because it motivates and stimulates active involvement. Taken this subject-specificity position as a starting point we assume that
students' IPS-skill can best be fostered in a problem-based curriculum in which instruction in the IPS-skill is embedded with the instruction in a lower-order skill. The next question that arises is how an educational programme must be designed in which the two types of skills (lower/higher) are integrated. In our view the used design model should be a model based upon recent cognitive psychological ideas about learning and problem solving. The Four Component Instructional Design (4C-ID) model (Van Merriënboer, 1997; Van Merriënboer, Clark, & De Croock, 2002) is such a model. Project in this line of research will be conducted to study the effect of embedded instruction on students IPS-skill and the involved lower order skill. Research in this line concerning instruction fostering IPS will also give a broader perspective on instruction in higher-order skills in general.

To conclude, characteristic research questions in this theme relate to uncovering the strategies and processes that students employ when search the Internet for information, learning from multiple hypertext documents, judge the trustworthiness of information and sources they find on the internet, and how they integrate information from different sources to construct knowledge. Finally, research on innovative ways of assessing IPS is carried out. Tools for providing instructional support to foster the acquisition of IPS skills will be designed, developed and their effects will be studied.

**Theme 3: Development of Domain-specific Expertise**

The development of domain-specific, vocational and professional expertise extends from school – often rooted in and affected by pre- or non-school learning – far into adulthood and - depending on the learner - reaching very high levels of performance often never reached within the school. Professional and vocational education aims at training students in such a way that they are competent enough to enter the workplace. Though practices in secondary education tend to unravel broad competencies into detailed constituent competencies that integrate knowledge, skill and attitude, higher vocational education and professional schools at the university level rather formulate broad competences. A profession like medicine sticks to about six key competencies (see for instance Frank, 2005) that are characteristic for professional job performance and together define a person’s level of expertise.

Training for the professions does not stop when one enters the workplace; learners often then enter a new phase. Expertise development research spans the whole range from very beginner to the top expert in a specific field taking many different perspectives:

- **cognitive** perspective focussing the changes in the knowledge structure a person builds on the way from novice to expert;
- **performance** perspective which regards the interplay between the knowledge structures that a person has arrived at and the typical and atypical problems of the domain. Performance is both cognitive (i.e., reasoning, problem solving) and behavioural (i.e., actions);
- **teaching and learning** perspective which is directly dependent on the level of expertise reached. Teaching and learning can be formal, informal or non-formal and change dramatically on the transition from school to work;
- **career** perspective which integrates questions related to changes in personal circumstances as well as changes in the profession itself. Changes in the profession, innovations or economic and societal change may require both formal and informal new learning which may be helped or hindered by previous expertise; and
- **neuronal and physiological maturation and decline** perspective which is a question in itself but is strongly related to all four other perspectives.

Expertise, experience and age are largely intertwined in these perspectives. Research that has been done has primarily dealt with the first two perspectives in several domains such as medicine, teaching, mental health and accountancy with the majority within the domain of medicine. Though this is the case, there are indications that those findings generalise to a much broader set of professions. The outcomes of the research are summarised in Table 1.
The third perspective – that of teaching and learning for expertise - has primarily been studied by Anders Ericsson and his colleagues, which has led to the theory of deliberate practice (see, for example, Ericsson, 2009). Ericsson places the concept of sustainable expert performance at the centre and shows that both the relation between teaching/teacher and learning/learner and the role of motivation and self-direction experience remarkable changes on their journey way from novice to expert (see also Alexander, 2003). Ericsson also shows that this continuous striving for the highest possible result introduces new ways and methods into practice and hence improves practice as well. Matching this theory on the stages of expertise development in professional domains shows that novices learn primarily from codified knowledge through formal education.

Research in the other two themes in the Learning and Cognition Programme usually deal with this stage of development. Intermediates in the profession typically learn from experience in the workplace. In most professional domains this stage is neither well researched nor educationally well-developed. The minimal approach in this stage is that learners act or work under supervision rendering their learning mainly implicit. Yet research, for example, in the sport and arts domains has shown that learning form experience can be greatly improved when this learning is properly designed. Important problems to tackle are feedback quality, as workplaces can be notoriously lacking in this respect, which not only affects the quality of learning but also affects the quality of professional performance (see Bransford & Schwartz, 2010). Another important aspect is the quality of the experience. Intermediates have been shown to not learn very much from routine cases. They need to work on a case mix that challenges the competencies that they have to develop. This requirement can be at odds with the workplace policies and safety requirements or performance standards set for that practice. In such a case, special precautions in terms of supervision and preparatory training are needed (Dornan, Scherpbier, & Spencer, 2008).

Even more advanced stages of expertise and experience have their own problems. From an educational point of view the most important problem here lies in the prevention of
arrested development. In domains where the working environment is characterised by low feedback qualities, professionals run the risk of learning the wrong things implicitly, which can turn them into practitioners that are incompetent without knowing that themselves.

The issue links the teaching and learning perspective to the career perspective as it is also in the hands of the profession itself to determine and organise how typical careers in a domain are organised. In some domains and workplaces typical careers are lifetime commitments to one profession (i.e., teaching and medicine). Other domains (e.g., the army) employ their personnel for shorter periods of their working life, requiring that workers make mid-career changes, building on the expertise developed. Individual careers are also highly influenced by personal factors and life events.

The fifth and final perspective links advanced learning and professional performance to a person’s age and her/his age-related physiological and neurological condition. Typical graphical representations of the relation between age and professional performance suggest a decline after a certain stage. The empirical ground for such graphs is thin, while the few studies that compared professional performance of beginner up to high levels of experience show a monotonically increasing relation (see, for example, Arts, Boshuizen, & Gijselaers, 2006; Hobus, Hofstra, Boshuizen, & Schmidt, 1988; Mieg, 2009). This may be a true effect of expertise development, but it may also be due to attrition. Ageing research has shown that learning capability decreases with age, but that higher levels of education and cognitive activity prevent or delay this decline. Similarly, there are indications that older professionals are more susceptible to the so-called set or Einstellung effect. For instance, Eva and Cunnington (2006) have shown that older (>60 years old) physicians are much less affected by new information that contradicts their set hypotheses than younger colleagues. However, research by Bilalić, McLeod and Gobet (2008) suggests that this effect can also be an affect of arrested development, as high levels of expertise protect against the set effect.

Research strategy
All five perspectives entail problems that can have major implications for learning design. A good model of the interaction of experience, age and expertise, localised to the specific domain, can help develop instructional environments, strategies and interventions targeted at the problems revealed this way. In the coming planning period we want to investigate three broad topics:

- Further validation of the cognitive restructuring model in fields characterised by visual processing. Visual learning has more implicit aspects than fields that can be well expressed in verbal mode and has immediate implication for educational design. So far both methods for visual stimulus presentation as well as methods for data collection and analysis were not readily available. Recent technological developments allow renewed interest in this field.

- Learning from experience at early and mid-career stages. Though workplace-learning research has a long tradition, it is mainly focused on investigating the effects of natural variations. Integration with expertise development theories will allow the design of targeted interventions of which the effects will be studied as well.

- The relation between experience, expertise and aging. Doing research on this relation requires a measure for expertise performance approach with agreed upon standards for performance (Ericsson, 2009). The central questions to be investigated will be: What are the effects of cognitive aging on professional learning and performance? and Do high levels of expertise protect against these effects? Detailed research questions will be developed in cooperation with the new assistant and associate professors in this Programme.

In addition to the three themes, the Programme has begun work on the possible addition of a fourth theme focussed on 'Brain and cognition'. In the first two years of the current
programme possibilities will be explored to determine whether there is a sufficient mass to warrant expansion.

**Brain, learning and cognition**

The theme will centre on bridging the gap between educational practice, neuroscience, and educational science respectively. This will be attempted through the investigation of the psychobiological determinants of lifelong learning and cognition and translating this into for the general public relevant advice and interventions. Specific neuropsychological topics which might be investigated in this theme will concern aging effects, sleep, vitality and fatigue influences, a diverse range of nutritional concepts, motivation, stress, exercise, and self-regulation.

Cross-bridges between existing themes and this new Programme will be formed by integrating knowledge from this theme into existing themes, for example with programme 3 where neuropsychological determinants can add additional knowledge for professional learning and expertise development in an aging perspective. The other way around, current themes are will also be encouraged to participate in new projects within the proposed new theme. A possibility to explore might concern a longitudinal (multi-centre?) study into the determinants of successful academic study behaviour in older populations (i.e., 25-40 years old and thus the typical student at the Open Universiteit) than in the population generally studies (i.e., 15-22 years old).

**9. Laboratories (Open Innovation)**

The general aim of CELSTEC Laboratories is to act successfully as a main driver for innovation in the fields of improved education & training, improved (continuing) professional development and improved learning experiences. The Laboratories work according to an open innovation model in which CELSTEC staff, OU Faculty Staff and Partners in the private and public sector work together to explore, co-develop and test innovations. They form an iterative circle with Research and Solutions (see Figure 3).

In the Learning and Cognition program, the innovations are steered by guidelines derived from Research (a). By means of developmental research these innovations are tested and refined within Laboratories (b). The innovations will be used to support Solutions (c) and Solutions could yield requests that could be incorporated in the innovations (d). Furthermore, research findings form the input for Solutions (e) while these activities could also yield initiatives for joined field experiments (f).

![Figure 3. Relationship between Research, Laboratories and Solutions and the processes that take place between them.](image-url)
Together with external partners or OU Faculty staff, staff of the L&C Programme can explore, co-develop, and test innovations in - amongst others - the following areas:

- Instruments, tools and techniques that aim to facilitate learning.
- Flexible learning environments that aim at personalising learning material to the needs of the learner.
- Usability.

**Instruments, tools and techniques**

In the past and present, prototypical instruments, tools and techniques have been developed for research purposes. In Laboratories, these prototypes can be further developed to a level that they can be tested in the OU faculties and ultimately used within Solutions.

**Teaching/instruction oriented innovations.** The teaching/instruction oriented innovations aim at supporting teachers and instructors/trainers in designing learning tasks, a training or curriculum or assessing their students. Stoof (PhD in 2005\(^1\)), for instance, developed a tool "COMET" (Competence Modeling Toolkit) that can be used to identify and describe competencies. In six steps, this web-based tool helps educational practitioners to construct a competence map. COMET consists of a task manager (i.e., information on when to take which step), a construction kit (i.e., tools that support user's during each step), a phenomenarium (i.e., examples to illustrate the application of the steps) and an information bank (i.e., descriptions of each step) to help practitioners during each step. Boot (PhD in 2005) provides three building-block solutions to help educational practitioners formulate a functional model of their instructional design and produce instructional software based on this design. The building block solutions aim at supporting practitioners to create design documents and programming structures and reuse learning materials. Furthermore, Hoogveld (PhD in 2003) developed an Instructional Systems Design training for individual and group learning to help educational practitioners design competency-based education. Schellekens (PhD in 2004) built a simulation with the object-oriented simulation software package D-SOL that can be used by educational practitioners to evaluate innovative curricula by means of simulating the flow of students through the courses in a new and old situation and compare the outcome of both runs. Moreover, several prototypes were developed to aid the instructional practitioners in evaluating their assessments. For example, Baartman (PhD in 2008) developed an instrument for evaluating assessment in competence-based education called a Competence Assessment Program (CAP). A CAP describes a framework of quality criteria that can be used by educational practitioners to evaluate the quality of their assessments. Gulikers (PhD in 2006) provided a five-dimensional framework for authentic assessment that helps educational practitioners evaluate the authenticity of their assessments. This framework consists of the dimensions: task, physical context, social context, form/result and criteria. Furthermore, new assessment techniques for research and educational purposes have been developed by Van Gog (PhD in 2006). She used cued retrospective reporting by means of recorded eye movements to uncover cognitive processes. This information can be used to guide the development of instructional material. Walraven (PhD in 2008) developed learning environments that foster transfer of higher order skills, Joosten-ten Brinke (PhD in 2008) provides procedures for evaluating and accrediting prior learning (EVC) and F. Kirschner (PhD in 2009) developed an instrument to measure group cognitive load during task performance.

**Student/learner oriented innovations.** The student/learner oriented innovations aim at supporting students, learners and trainees during their learning process. A number of

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\(^1\) For a list of PhD dissertations see Chapter 21. Dissertations or http://celstec.org/node/179.
Instruments, tools and techniques have been developed that aim at supporting group learning. Beers (PhD in 2005), for example, developed Negotiation Tool (NTool). NTool is based on a newsgroup reader, featuring (a) synchronous, distributed, text-based discussions. To optimize the NTool for negotiations among group members a collaboration script was incorporated to structure the negotiation process. Bitter-Rijpkema (PhD in 2005) developed IdeaSticker that aims to support collaborative dialogues during problem solving. It is an aid to structure communication by providing structure fields: I propose, Because, Evidence, Expectations, Actions needed and Response requested. Furthermore she developed Augmentation of Collaborative Elicitation (ACE) forum. ACE forum aims at knowledge elicitation and knowledge co-construction. It consists of a prompting function (i.e., hints that give action and reflection advice) and enabling functions (i.e., presence indicator, mind mapping, meta-tagging, scoring and voting mechanisms).

Learning environments to support the students learning process have also been developed. Kester (PhD in 2003) and Van Gog (PhD in 2006) both developed environments using simulations to teach students how to troubleshoot electrical circuits. Tabbers (PhD in 2002) developed a web-based, multimedia environment to teach student-teachers how to design instruction according to the Four Component Instructional Design model (Van Merriënboer, 1997). Nadolski (PhD in 2004) and Hummel (PhD in 2005) developed multimedia practicals for both individual and group learning in the domain of Law. Salden (PhD in 2005) and Corbalán (PhD in 2008) developed adaptive learning environments for aviation training (Salden) and for basic dietetics and genetics training (Corbalán). Wouters (PhD in 2007) developed animated practicals to teach students probability calculation. Sluijsmans (PhD in 2002) developed a training to teach student-teachers how to assess each other. Kicken (PhD in 2008) developed a prototype of a learner portfolio that helps students self-regulate their learning. Kostons (expected PhD in 2010), Taminiau (expected PhD in 2012), Gorissen (expected PhD in 2012), and Van Meeuwen (expected PhD in 2013) focus on the development of learning environments that support students to self-regulate their learning.

Flexible learning environments

Based on Research, tools for flexible learning may be developed, such as, technical solutions for implementing assessment and task-selection algorithms in F2F and e-learning environments, or rapid assessment techniques that can provide (almost) real-time input for task selection in F2F or e-learning environments (cf. Kalyuga, 2006). There is a need for algorithms that not only rely on assessment of variables of the task just completed, but also take into account the history of task performance (cf. Corbalán, 2008). As for rapid assessment techniques, there is a need for technology that can make the analysis of for example verbal protocols, eye tracking, and concept mapping data less time consuming, so that these assessment techniques might also (in the future) play a role in adaptive task selection.

This non-exhaustive overview gives an idea of the instruments, tools and techniques that have been or are developed for research purposes. Within Laboratories an effort is made to make an inventory of the most promising instruments, tools, and techniques, further develop them in collaboration with the OU faculties and ultimately embed them in Solutions.

Usability

Finally, based on experiences with process-based techniques for performance assessment and assessment of cognitive processes, together with clients we can explore usability questions to improve the design of websites, advertisements, or electronic learning environments/materials they intend to use. Eye tracking can provide unique insight into what information people attend to, in what order, and for how long. Combined with verbal protocol or interview data, it provides an insight in what people are doing and why. These
insights can give answers to questions such as: What is the best place to put my advertisement on this website? How fast can people find the information they are looking for on my company’s website? Do learners attend to the right information in our new learning environment or do they experience navigation problems? Etc.

10. Solutions and Education & Training

An increasingly important part of the work in science and education is to make the results of research and laboratory activities accessible and applicable to partners in society, who are looking for solutions for both learning problems and instructional design problems. Solutions and Education & Training provide the means to do so. Analyses of actual requests from partners in the field of education and company training to the L&C Solutions Programme are expected to uncover topics of interest that either fit to the important research questions in the three themes of the L&C Programme, or provide new opportunities to innovation in education and company training.

One major topic is teacher education. As a consequence of a new law (the so called BIO-law), Dutch institutes for teacher education are involved in a curriculum reform focusing on the acquisition of new teacher competencies that support flexible learning strategies for their school’s children. The reform aims also at a full integration of theoretical teaching principles in the practical training of future teachers. In this context, the 4C-ID methodology and the Information Problem Solving Approach have proven to be powerful supports for teacher. Here the programme will work closely with the Ruud de Moor centre and NeLLL.

Another topic, where CELSTEC more frequently is asked for support, is situated in an important sector in education: the middle vocational education. Students in this sector of education struggle with problems of motivation, based on the low level of integration of theory and practice. To remedy this problem, the Dutch Ministry of Education has imposed a target on this sector to redesign its curriculum as fully competency-based. This development is recognised as a challenge for CELSTEC. It is believed that the positive results of innovative pilot-research projects that CELSTEC has conducted in cooperation with schools for middle education (flexible student portfolio and flexible pathway’s) will contribute to development of sustainable solutions.

A further topic of interest is blended education, not only in the educational, but also in industrial settings. It requires a variation between classroom education and guided self-study (in distance format). Instead of only delivery of content, design of this type of education requires a combination of theoretical principles, problem tasks to apply these principles and an approach for guidance, tutoring and feedback on student performance. For this, the flexible environments being developed within the program offer usable solutions. Also, in industrial settings this approach is shown to contribute to the prevention of absence of trainees in the workplace. Therefore, in industrial settings this format of education is also used as workplace learning. Teachers and instructors are in most cases not familiar with the typical aspects of the coaching role in combination with organisation of courses for independent study. In a number of cases L&C expertise might therefore be required for support of change management.

A final topic relates to the earlier mentioned broadening of the programme to include research and development relating to brain, learning, and cognition. We expect that the research carried out within the programme as well as in cooperation with other important partners in the field will lead to new knowledge about the complex interactions between different determinants of formal lifelong learning, which in turn will lead to diverse solutions for learning and instruction. For example, we endeavour to promote personalized learning
strategies that will stimulate and facilitate lifelong learning and successful cognitive aging. In addition we aim to develop more effective instructional designs for adult learning.

Solutions
These activities thus provide clients with customised solutions for their instructional design questions. They encompass customised training trajectories as well as consultancy and coaching. Consultancy and coaching include mostly a mix of Solutions activities: informing, training and advising. They can be called upon in different phases of design. For example in the preparation phase of a curriculum (re-)design, consultancy could be offered in designing a curriculum blueprint, but also in the subsequent development and implementation phases consultancy and guidance can be offered. Frequently, tools, developed previously are applicable in these trajectories, e.g., E-space, a tool for supporting peer-assessment and peer-feedback, or ‘Teleforum’, a design method for guidance of on-line tutoring or of multipoint on-line instructional events, the outcome of ‘Opleiden voor de toekomst’ [Training for the Future] (see: Hoogveld & Jansen, 2007) is re-applied in redesign of teacher training institutes.

Further, in the context of the L&C Programme, studies can be hosted for third parties who are interested in using our research techniques or equipment (e.g., the eye tracking lab for usability studies or assistance in setting up cued retrospection techniques in the partner’s research project). As an open innovation activity, those activities could also be employed as a joint exploration with a company. For instance, the development of expert-based worked examples with eye movements implemented, could be a joint exploration between the L&C Programme and a company that provides eye-tracking solutions, such as Tobii.

Offering tailor made solutions for instructional design problems in participation with different clients will probably also result in new research questions and laboratory activities, completing the circle of these three activities (see again Figure 2).

In addition to this, lectures, site visits, symposia, workshops and the set up of a easily accessible interactive website belong to the possibilities.

Evidence-based educational innovations will be applied in schools, institutes for higher education, as well as in companies and instruments will be developed that will, hopefully, be able to measure the most important determinants of lifelong learning.

Education & Training
Education and training trajectories are offered, that aim to inform clients about the design guidelines, models, and tools developed in the programme and/or to train them in how to apply them in their own institute/company, as well as to inform them about new scientific insights, which can be implemented in current curricula. Examples of education and training options currently available at CELSTEC and powered by the L&C Programme are:

- A course on the four-component instructional design (4C-ID) model in the Master Learning Sciences. This course is part of the Master’s program, but can also be followed in isolation and is certified
- A course for teachers on 'teaching students information problem solving skills'. This course is provided together with the Ruud de Moor Centre and is certified
- A half-day, one-day, or three-day training on applying the 4C-ID methodology
- Workshops on designing and implementing different modes of assessment (e.g., performance assessment, peer assessment)
- A workshop for teachers on recent insights from neuroscience and their implications for the educational field
- Workshops for high school students with respect to different topics relating to their study, their learning, and the factors that influence this
- Workshops for teachers about neuromyths (urban legends), gaming and learning, nutrition and the brain, motivation and competence, choice behaviour, the aging teacher, influences of sleep, sex differences
- Interactive workshops for parents about the afore-mentioned topics
- Lectures for the general public about the afore-mentioned topics
- Scientific conferences/symposia on the research in the L&C Programme

New education and training activities based on current and future projects can be added, which can be followed as single units or can complement those mentioned above:
- Workshops on the design of authentic learning tasks and assessments;
- Workshops on the design of e-learning tasks and environments;
- Basic Qualification in Education with respect to the use of media and teacher extensive education (use of the CELSTEC-developed IPO-BKO offer)
- Via the OUNL’s Open educational resources programme, short introductions to courses, workshops, and training programs mentioned above will be available. These provide a quick overview of the content of a course/workshop/training and, as such, serve both to provide information and as a kind of ‘teaser trailer’.

In addition, within the OU, knowledge and expertise available in the L&C Programme may be called upon for:
- Master of Learning Sciences courses, such as for instance, ‘research methods for educational design’, ‘methods and strategies for instructional design’, ‘evaluation of educational innovations’, and the mini-conferences organised by the Master Programme.
- ‘IPO’, the OU-wide educational innovation program, in which CELSTEC employees from this Programme participate, for example in projects such as ‘the virtual classroom’, ‘the new study-net’, and ‘online assessment’. IPO ended in 2009, but has been continued indefinitely with IPO-2.
- Developing and offering instructional design solutions together with the RdMC, the OU’s centre for teacher professionalisation. An example of such a collaboration concerns the development of a course for teaching students information problem solving skills (see above) and ‘Inspirator’ a project to increase awareness of teachers of opportunities of learning in their workplace. (see: www.ou.nl/inspirator)

Cooperation of CELSTEC with RdMC will offer complementary service to the field of teacher training.

Relationships between Themes (and the Elements)
The three themes of the L&C Programme - flexible environments for acquiring complex skills, solving complex information problems, and development of domain specific expertise - are integrally related to each other. Solving complex information problems is a highly complex skill that needs to be acquired by all modern day learners and that is highly dependent upon the availability of domain-specific expertise. Flexible environments for acquiring complex skills are extremely suited to acquiring and developing complex information problem solving skills within a specific domain. And optimally acquiring and developing domain-specific expertise requires being able to solve complex information problems (whose difficulty varies with the level of expertise) in environments that are adaptive to the learner’s level of expertise.

In addition to the relationships between the themes, there is a holistic relationship between the themes and the elements described earlier. As such, learning tasks, learning environments, and learning assessment form the guiding principles for the research themes of the programme. Learning – formal, non-formal or informal – takes place in learning
environments based upon learning tasks which need to be properly assessed and archived (e.g., in portfolios) both formatively and summatively. These environments can be fixed or flexible/adaptive. As such, the three research themes will all be concerned with these elements in an organic way. For example, the ‘expertise development’ theme will study learning tasks for expertise development (by novices and/or experts), learning environments for facilitating expertise development and assessment of expertise.

![Figure 4. The Relationship between Learning Tasks, Environments and Assessments](image)

**Relationships between Research, Laboratories, and Solutions**

Research within the three themes feeds into Open Innovations through Solutions. However, what starts as an isolated activity of solving a dedicated problem for a dedicated client, can become the start of an exploration or cooperative approach between institutions of education and research. Sometimes Research marks the start of Solution trajectories, sometimes new educational problems that are interesting to research, will be identified through Solutions. Ideally, Solutions arise after successful testing of Research results in pilot projects. Sometimes small Solutions activities give raise to cooperation and testing of theories, as shown in the case of the 4C-ID casebook, to which a number of institutions and authors contribute on a voluntary basis. Finally, laboratory activities can also inspire further research, as the partnerships formed to explore, develop, and test innovations are likely to not only answer several questions, but also raise new ones. If these questions are not only practically, but also scientifically relevant, new Research projects may be submitted by staff in the L&G Programme to study those questions (i.e., funded internally). If these questions primarily have practical relevance, there is the option to jointly seek external funding with the partners involved.

Both research and laboratory activities feed into Solutions by new requests of clients for support in instructional design and for training in instructional design skills. However, again, this also goes the other way around: from partners to whom Solutions have been provided, new questions for research and laboratory activities can arise (see Figure 3).

**CELSSTEC Lab Facilities**

CELSSTEC maintains a modern media Lab (OU MediaLab) that was established as a research and innovative environment to promote and conduct empirical research, to test advanced learning technologies, and to explore, co-develop and test innovations collaboratively with OU Faculty Staff and external Partners. It consists of several rooms that allow for flexible use (for details see "CELSSTEC Laboratory" document). The MediaLab supports the following tasks:

- **Incubation**: The generation and expression of new ideas for learning and teaching.
- **Research and technology development**: The MediaLab will enable research and development projects to develop and configure appropriate media prototypes for exploration and experimentation.
Media technology scouting: In view of the high innovation rate of media technologies, i.e. wideband internet, mobile networks and consumer electronics, the MediaLab keeps track of new media opportunities for learning.

Sensibilisation and dissemination: The MediaLab will also be used for displaying state of the art technologies, concepts and practices for media experts, educators and possible user groups through seminars, showcases and workshops.

Open innovation workspace: It will offer the opportunity joint projects and experiments with internal and external partners, for instance research institutes, education providers, cultural institutions, technology and network providers and industry partners. It thus may act as a media knowledge hub and broker between parties. The MediaLab thereby amplifies the networking role of the Open Universiteit, helps fund raising and stimulates initiative and entrepreneurship.

11. The External Environment

The external environment of the L&C Programme consists of various organisations, associations, funding programmes, research institutes, companies, and conferences.

Research School

The research activities of the Programme are allied to the Interuniversity Centre for Educational Research (ICO) research school, which is recognised by the Royal Dutch Academy of Sciences. The general mission of ICO is to advance scientific theories for understanding processes and systems of learning and instruction. Participants are faculty departments and research centres from 10 Dutch universities. There are also two associated Dutch universities and three associated Flemish universities. ICO encompasses approximately 105 staff members and 90 PhD candidates. PhD candidates are appointed at the different universities. For the 2004-2009 recognition period, the ICO research Programme was centred around the following six themes: Theme I (Innovative Learning Environments) and Theme II (Teaching and Teacher Education) focus on the micro-level of the educational process by studying the learner, the teacher, and the learning environment. The micro-level is also the focus of Theme III (Domain Specific Instruction) but from a domain specific stance. Theme IV (Educational Design and Curriculum Development) concentrates on the process of the design of instructional arrangements both at a learning environment and curriculum level. Theme V (Schools and the Societal Context of Education) studies the macro-level of the educational process by studying organisational aspects (schools, government, society). Finally, Theme VI (Assessment, Evaluation, and Examination) specialises in questions around measurement of educational outcomes.

Prof. dr. Paul A. Kirschner is co-coordinator of Theme I, Monique Bijker MSc is co-coordinator of Theme III, and Dr. Saskia Brand-Gruwel and Ir. Ludo van Meeuwen are co-coordinators of theme IV.

Relevant Partners for Research, Laboratories, and Solutions outside the OU

There are a number of partners with whom the L&C Programme currently collaborates on Research and Open Innovation, and to whom Solutions or Education & Training are provided. This list is not exhaustive, but gives an impression of the kind of partnerships in which this Programme continues to engage or that can be newly established.

Teleac/NOT

This is the public broadcasting organisation for educational media in the Netherlands. As a broadcaster Teleac/NOT increasingly orientates on innovative cross media platforms and
content. Importantly, Teleac/NOT and the Open Universiteit have agreed on strategic cooperation, especially in the area of lifelong learning. Prof. dr. R. Martens holds a special chair on multi-media education funded by Teleac and the OU.

**LVNL/NLR/KDC**

With the Air Traffic Control of the Netherlands (LVNL) and the National Aerospace Laboratory (NLR) and the Knowledge Development Centre main port Schiphol (KDC) we work together on different research projects about the instructional design of the air traffic controllers training. Main aim is to design flexible learning environments because new technologies, innovative operational concepts, and changes in the coordination of the aviation chain constantly affect the competences that are required not only of the Air Traffic Management organisation, but also of the individual air traffic controllers.

**ROC-A12**

Together with this organisation for secondary vocational education research is conducted in order to redesign their curriculum in the sector ‘care and welfare’.

**Other**

- In a number of projects CELSTEC supports (primary) teacher training institutes in redesign of curriculum into a competency based one. A project with Fontys University for professional education is successfully concluded with an implemented curriculum.
- Philips Healthcare Systems is interested in support in distance deliverable blended education and redesign of training.
- For USEM, an international project empowering national organisations for handicapped people to participate in European standardisation discussions a training is developed for the project team to realize self-directed distance learning of standardisation concepts for handicapped people and thus promote participation.
- The Netherlands’ army and marines academy is being supported in design, implementation of an environment for blended learning.
- AVANS university of professional education in Breda is being helped in teaching their teachers to set up and carry out research.
- Cooperation with Ruud de Moor Centre at the Open Universiteit in design of instruments for workplace learning of teachers in Dutch schools results in the environment: Inspirator.
- Accreditation of Belgian universities for professional education in the programmes for tourism and recreation management.
- After a successful training of the European Patent Office in 2002 also the Netherlands Patent Office is offered consultancy and training, considering the revision of their trainee education.
- From the Life Long Learning Limburg project, a re-schooling project and mobility centre running in cooperation with partners from education, industries and provincial government, participation is requested from CELSTEC Solutions, L&C for development of an educational vision for flexible learning.
- Via the Netherlands’ Business Support Office in Frankfurt, Germany, intensified contact with high tech industries or training companies is sought to explore new paths for in company training, enabling knowledge workers to develop highly needed new learning methods and learning competencies (Klemke, Hoogveld & de Vries, 2010). These idea’s will also be communicated with regional high tech Dutch industries.
• PRORAIL the Netherlands' railway infrastructure company requests CELSTEC L&C Solutions to partner in research and training of rail traffic controllers and engine driver, using Eye movement registration techniques.

StOER a new instrument of the OU to promote Communication with external parties
Within the context of CELSTEC, the L&C Programme actively participates in the StOER project, which intends to interest new target groups or existing relations to form communities of interest in the research themes, the labs and solutions from L&C. Topic communities: 4C-ID, Professional development and Solving complex information problems are set up. More communities will follow.

Funding Programmes

NWO, the Netherlands Organisation for Scientific Research
This organisation is the main body for influencing the course of Dutch science by means of subsidies and research programmes. NWO’s educational research programme (PROO) provides the main opportunity for the L&C Programme to get research projects funded, others include the Open Competition Social Sciences (MaGW) and the Innovational Research Incentives Scheme (Veni, Vidi, and Vici grants).

SenterNovem
This is an agency of the Dutch Ministry of Economic Affairs which aims to promote innovation in service of positive effects on the economy and society as a whole. It acts as the Dutch Liaison of the European Union and its funding programmes. But it also offers separate funding for activities in the area of technology, energy, environment, export and international cooperation. Occasionally, funding covers educational themes.

SURF
This collaborative organisation for higher education institutions and research institutes is aimed at breakthrough innovations in ICT. SURF provides the foundation for the excellence of higher education and research in the Netherlands. SURF consists of three organisations that each have their own field of activity: ‘SURFfoundation’, ‘SURFnet’ and ‘SURFdiensten’. Surf also grants research in the field of ICT in education.

7th Research Framework Programme of the EU
This programme is one of the main financial tools through which the European Union supports research and development activities covering almost all scientific disciplines. It is proposed by the European Commission and adopted by Council and the European Parliament following a co-decision procedure.

Kennisnet
Kennisnet Foundation is a public body that provides ICT support for schools, looks after their interests, and promotes innovative approaches of education with ICT. Because of the susceptibility of young learners for new media and devices, Kennisnet is an interesting party for co-operation. Among others, Kennisnet has a programme called ‘Kennis van waarde maken’ (making valuable knowledge and making knowledge valuable) for funding research projects concerning ICT in education.

LIOf, Limburg entrepreneurial funding organisation
Provides support for starting entrepreneurs, also promoting international business location. This target group perfectly fits in the research theme of development of domain specific expertise.
National and International Research Institutes

ITS
This independent institute, connected to the Radboud University in Nijmegen specialises in social scientific research, policy advice, company research and knowledge transfer, utilising the most modern methods. It has research experience in education, healthcare, labour, mobility and social security. Prof. dr. Ton Mooij holds a special chair on educational technology funded by ITS and the OU.

Psychology Department at Erasmus University Rotterdam (EUR)
There exists close research collaboration with the Psychology Department at EUR. Recently, an interlinked research project on ‘Fostering self-monitoring and self-regulation in primary and secondary education’ (2009-2013) was subsidised by NWO/PROO. Prof. dr. Fred Paas – ex-chair of the L&C Programme, holds a professorship in educational psychology at the department of psychology of EUR.

Maastricht University (UM)
The department of Psychology has been the main supplier of interns and PhD students. In addition, joint research meetings are organised with the department of Education and Development. Main collaborators are Prof. dr. Cees van der Vleuten and Prof. dr. Jeroen van Merriënboer.

Open University of Catalonia, eLearn Centre
Prof. dr. Paul A. Kirschner is visiting professor at the eLearn Centre of the UOC, an e-learning research, innovation and training centre, focusing on higher education and lifelong learning. Its main objectives are (1) contributing to research and innovation in the use of technologies for learning and training, (2) encouraging best practices in education, based on the use of ICTs to improve teaching and learning processes and (3) encouraging training in e-learning with a range of higher education. Main collaborators are Prof. dr. Begoña Gros and Dr. Elena Barbera Gregori.

Knowledge Media Research Center, Tübingen, Germany
Knowledge acquisition, exchange and communication within innovative technologies are the core research at the Knowledge Media Research Center in Tübingen, Germany. Study matters are classic forms of teaching and in-class education in higher education and school domains as well as possibilities of learning in informal settings, like museums, internet and workspace. A multidisciplinary team of highly trained scientists from cognitive and educational sciences, social and (human) behavioural sciences is completed by experts from media technology and computer science. By cooperating closely with public and private institutions and transferring research results into real world-applications, the institute makes a substantial contribution to realising innovative media-based teaching and learning scenarios. Main partners are Prof. dr. Friedrich Hesse, Prof. dr. Peter Gerjets, and Dr. Katharina Scheiter.

Learning Systems Institute, Florida State University, USA
The Learning Systems Institute maintains project-based teams led by FSU faculty and graduate students with a wide range of experience in many varied disciplines. These multidisciplinary teams develop robust solutions using systems approaches to the planning, design, evaluation, and improvement of instruction, learning, and human performance. Prof. Dr. Mike Spector (now at University of Atlanta) and Dr. Aubteen Darabi are two of the main collaborators.

School of Psychology, University of Wollongong, Australia
Research collaboration exists with Prof. dr. Paul Chandler, dean of the faculty of Education, at the University of Wollongong.
School of Education, University of New South Wales, Australia
Prof. dr. John Sweller, Dr. Paul Ayres, and Dr. Slava Kalyuga have been invited several times for stays to strengthen the research collaboration on "cognitive load theory and instructional design" between OU and UNSW.

Associations and Conferences

Membership and active participation (e.g., by involvement in the organisation of activities) in the following associations or their sub-associations is stimulated:

NERA/VOR
The Netherlands Educational Research Association (NERA, Dutch: Vereniging voor Onderwijs Research - VOR) is the official professional association for educational research in the Netherlands and the Dutch speaking part of Belgium. The Association was founded in 1975 and has approximately 600 members, and nine divisions. All members are associated with one or more divisions. The NERA also supports a 'tenth division' namely the NERA Council for PhD candidates (Dutch: VOR Promovendi Overleg, VPO). Dr. Brand-Gruwel is Treasurer and member of the Executive Committee of the NERA and Prof. dr. R. Martens is in the board of the Higher Education division. The NERA organises the yearly Dutch/Flemish ORD ('Onderwijs Research Dagen'/Educational Research Days) and publishes the journal 'Pedagogische Studiën' (Pedagogical Studies).

AERA
The American Educational Research Association (AERA) organises the annual AERA meetings, which are prominent conferences with a broad scope. The AERA publishes a large set of scientific journals, including Educational Researcher and Review of Educational Research.

AECT
The Association for Educational Communications and Technology (AECT), organises the yearly AECT conference and publishes Educational Technology Research and Development.

EADTU
The European Association of Distance Teaching Universities (EADTU) is the representative organisation of both the European open and distance learning universities and of the national consortia of higher education institutions that are active in the field of distance education and e-learning. EADTU organises world conferences and initiates innovative European projects which often address urgent topics of distance learning.

ISLS
The International Society of the Learning Sciences (ISLS) is a professional society dedicated to the interdisciplinary empirical investigation of learning as it exists in real-world settings and how learning may be facilitated both with and without technology. The society is widely interdisciplinary and includes members from cognitive science, educational psychology, computer science, anthropology, sociology, information sciences, neurosciences, education, design studies, instructional design, and other fields. Currently the society includes members from six continents and provides unprecedented opportunities for collegial interaction across national boundaries in this field. ISLS organises the biannual CSCL (International Conference on Computer Supported Collaborative Learning – in uneven years) and the biannual ICLS (International Conference of the Learning Sciences – in even years). ISLS publishes the International Journal of Computer Support for Collaborative Learning (iJCSCL) and the Journal of the Learning Sciences (JLS). Prof. dr. Paul A. Kirschner is president of the society.

EARLI
The European Association for Research on Learning and Instruction (EARLI), organises the biannual scientific EARLI conference, scientific Special Interest Group Meetings in the years between the biannual conferences, scientific JURE conferences for junior researchers (pre-
conference before EARLI biannual meeting and weekly conference in between years), as well as a yearly Practice-Based and Practitioner Research Conference. EARLI publishes Educational Research Review and Learning and Instruction.

Other

ALT (Association for Learning Technology)
AACE (Association for the Advancement of Computers in Education)
EDEN (European Distance Education Network)
ICDE (International Council for Distance Education)
ISATT (International Study Association for Teachers and Teaching)
ISTE (International Society for Technology in Education).

12. Cooperation and Communication with OU Parties

Within CELSTEC

The present Programme should contribute to the overall CELSTEC mission together with the Programmes on Learning Media and Learning Networks, and the Education & Training institute of CELSTEC. This mission concerns researching new methods and technologies for the advancement of adult learning, widely sharing research results, and helping other organisations to make good use of these results. Although the Programmes and the Education & Training institute have the same mission their focus differs. This guarantees the individuality of the Programmes. But it also allows to seek for overall topics that can be approached from different perspectives.

For example, both the L&C Programme and the Learning Networks Programme focus on competence building. However, whereas the first programme focuses on formal learning, the latter programme is directed at informal learning. So, a productive cross-fertilisation with regard to competence building is to be expected, rather than unproductive doubling of activities because the underlying principles of formal and informal learning are different and thus the perspectives on competence building are different as well. Furthermore, both the L&C Programme and the Learning Media Programme investigate 'immersion media'. This type of media includes virtual laboratories, virtual practicals, computational simulations, serious games, and virtual worlds. The L&C perspective on immersive media is to formulate guidelines for the application of immersive media in an educational context whereas the Learning Media Programme is concerned with how to improve learning by incorporating rich, immersion media that simulate real world practices into the learning material. The guidelines for multimedia learning investigated and developed in this Programme combined with the results of Learning Media Programme can strengthen the overall mission of CELSTEC.

Many areas of common interest exist between the L&C Programme and CELSTEC’s Education & Training institute. First of all, dissemination of research results, tools and guidelines developed from this Programme in the Master Programme Learning Sciences is done through papers, scientific and professional, presentations and keynotes, but also through workshops and courses. The development of courses and workshops are part of each programme’s Solutions task and the Education and Training Institute serves as the preferred outlet for this kind of Solutions. Furthermore, researchers of the present Programme participate in the Education and Training Institute in the role of teacher and/or course developer.
Outside CELSTEC

NeLLL. For any of its activities - research, Laboratory (Open Innovation) and Solutions - the L&C Programme stimulates collaboration with other parties in the OU. A prime candidate is the recently established Netherlands Laboratory for Lifelong Learning (NeLLL). NeLLL provides a fertile context for starting and conducting high-quality research contributing to the development of theories, concepts, models, instruments and tools that help to understand, facilitate, and realise lifelong learning. To fulfil this mission five programme lines representing five different perspectives on lifelong learning are foreseen: 1) Cognitive-educational perspective, 2) Learning-technologies perspective, 3) Personal and Professional-learning perspective, 4) Learning organisation and Learning region perspective, and 5) Teacher training perspective. The present Programme has the strongest relation with the first perspective. Most Research projects in the L&C Programme concerning lifelong learning will be put under the cognitive-educational umbrella of NeLLL.

RdMC. Solutions activities can also take the form of joint projects with the Ruud de Moor Centre (RdMC), the OU’s centre for professionalization of teachers. An example of such a collaboration concerns the development of a course for teachers on how to integrate instruction for information problem solving in a school curriculum. The RdMC has a network with a large number of schools (at all educational levels) in the Netherlands, and thereby such joint projects are a very effective way to bring knowledge and instruments/tools that have been developed in our Research to the market.

Faculties and IPO. The OU faculties can call upon CELSTEC employees for consultancy and support for educational innovations in their faculty. CELSTEC employees also participate substantially in 'IPO', a OU-wide educational innovation programme in which different educational innovation projects are run, of which the project team members come from both CELSTEC and several faculties.

13. Staff Allocation

In 2010 the Programme will be run by 21.5 full time equivalents (fte) of CELSTEC staff, with 20.0 fte and 1.5 fte for scientific and non-scientific staff, respectively. Within the scientific staff 50% of the fte is financed by the Open Universiteit’s direct funding, and 50% of the fte is financed by external resources. From a financial perspective, this division in internally and externally financed fte represents a 60%/40% ratio.

Table 2. Staff Allocation for the Programme Period

<table>
<thead>
<tr>
<th>Scientific staff</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fte</td>
<td>%€</td>
<td>fte</td>
<td>%€</td>
<td>fte</td>
</tr>
<tr>
<td>Internally funded</td>
<td>9,9</td>
<td>60</td>
<td>10</td>
<td>46</td>
<td>10</td>
</tr>
<tr>
<td>Externally funded</td>
<td>10,1</td>
<td>40</td>
<td>15</td>
<td>54</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>20,0</td>
<td>100</td>
<td>25</td>
<td>100</td>
<td>25</td>
</tr>
</tbody>
</table>

| Non-scientific staff | Internally funded (fte) | 1,5 | 3 | 3 | 3 | 3 |
|                      | Externally funded (fte) | 0   | 0 | 0 | 0 | 0 |
| Total                |                       | 1,5 | 3 | 3 | 3 | 3 |

*Financial consequences expressed in percentage of the scientific staff funding

For the coming years, the Programme aims at changing this ratio, in such a way that 40% of the scientific staff is financed by the Open Universiteit’s primary budget and 60% by external resources. This shift of 10% from direct to external funding in year 5 (2014) will be realised, on the one hand, by maintaining the current amount of research funding, and, on the other
Learning and Cognition Programme (2010-2014)

hand, by extending contracts. The latter will mainly be realised by activities related to Education & Training and Solutions. The basic assumption underlying this plan is that a stable core staff of 10 internally funded fte is needed to run the Programme successfully. The table below presents the yearly staff allocation and percentage of funding for the duration of the Programme.

14. Programme Organisation

The Programme Chair is responsible for thematic leadership, content-related validation and ultimately the quality and quantity of the research, laboratory, and solution activities carried out in the Programme. These activities are organised in three themes, which are each headed by a theme leader (at minimum at the associate professor level). The theme leaders are responsible for management and further development and deepening of the track by defining new projects and services, expanding the network, generating exposure, acquiring new funding and achieving agreed output. Each theme leader describes in a two-yearly theme plan how the general goals that are formulated in this programme plan will be more specifically realised. These plans can be adapted, on a yearly basis, to internal and external circumstances, such as changes of staff and market changes. All plans are finally agreed upon by the CELSTEC Management Team (MT). Besides full professors and associate professors, the staff comprises assistant professors, post-doc researchers, and PhD candidates. Staff members are allocated to the themes on a semi-permanent basis by taking into account available expertise, career ambitions and project requirements. The general organisational structure of CELSTEC is depicted in the chart below.

![Figure 5. CELSTEC Organization Chart of CELSTEC](chart)

The L&C Programme is one of three CELSTEC Programmes. Prof. dr. Paul A. Kirschner is Programme Chair, the three themes of flexible environments for acquiring complex skills, solving complex information problems, and development of domain specific expertise are led by dr. Liesbeth Kester, dr. Saskia Brand-Gruwel, and Prof. dr. Els Boshuizen, respectively. Solutions and Education and Training activities are managed by dr. Bert Hoogveld.

Staffing of the CELSTEC Programmes is arranged by a shared capacity group. A facility unit provides administrative and secretarial support. For coordination of the Programmes
various mechanisms exist. At the level of Research, Laboratories, and Solutions, separate coordinators are responsible for the alignment of activities, shared policies and shared procedures. Programme Chairs and co-ordinators have quarterly meetings chaired by the dean of CELSTEC. When appropriate the capacity manager and the head of facilities attend these meetings. The CELSTEC MT meets each month and consists of the Human Resource Manager, Director of Operations and the Dean.

The L&C Solutions co-ordinator operates under direct responsibility of the Programme Chair and in close collaboration with the theme leaders. His/Her tasks comprise the organisation of the internal and external contacts with stakeholders and clients, account management, propagate the services that can be delivered, develop new services. In addition, he prepares the project staffing in consultation with the Programme Chair and the HRM manager, and is responsible for a quality assurance system for L&C Solutions. The coordinator reports and discusses new opportunities on a regular basis to the Programme Management and in the plenary meetings (see the table below).

In addition to projects and activities that are positioned in the CELSTEC Programmes, 10 percent of the CELSTEC capacity is used for projects with a transcending or integrated nature, combining expertise on L&C, learning media, learning networks, and education curricula. Also, all CELSTEC Programmes contribute to the innovation of educational services of the Faculties of the OU through the Innovation Programme (IPO), which can be considered Solutions of CELSTEC expertise.

The organisational structure of the Programme goes with three types of meetings, that is, Programme management, Programme plenary and Theme meetings. The participants, agenda, duration and frequency of those meetings are described in the table below.

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Participants</th>
<th>Agenda</th>
<th>Duration</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programme management</td>
<td>All senior staff (i.e., those with project management tasks)</td>
<td>Strategies, policies, approval of projects and proposals, coordination, staffing, acquisition, publicity, facilities, external relationships</td>
<td>2 hours</td>
<td>Every six weeks</td>
</tr>
<tr>
<td>Programme plenary</td>
<td>All participants of the Programme</td>
<td>All relevant topics for the Programme</td>
<td>90 min</td>
<td>Monthly</td>
</tr>
<tr>
<td>Theme meeting</td>
<td>Theme leader and theme members</td>
<td>Projects, activities, proposals</td>
<td>1 hour</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

### 15. Projects

The L&C Programme is organised in projects, which begin on the basis of an approved project proposal, which clearly describes the planned input (i.e., human labour), throughput (i.e., people, processes, activities, resources), output (i.e., publications, tools, prototypes, instruments) and project management (i.e., time, money, quality, information, organisation). For each project a project team is formed. The team consists of:

**Project chair**

The project chair is integrally responsible for a project with respect to project content, methodology, organisation (production, planning, finance, evaluation, dissemination, etc.), and products.
Team members
The team members work on the project, under supervision of the project chair. The project chair can be the only team member, in the case of one-person teams.

Other participants
Other participants are scientific, technical, and support staff who participate in a project. Examples are: technical scientific designers or programmers, evaluation specialists, graphical designers, data entry staff, et cetera. Their support will often be confined to specific phases of the research project. These can also be external participants. Not only is national and international collaboration with experts in the field encouraged, but in projects that have a multidisciplinary approach (which is strongly encouraged) it may be necessary to call upon experts in other disciplines.

Proposal Submission
All staff members are eligible to submit a project proposal. This can be done individually or cooperatively as a group. Collaboration between staff members is encouraged.

The first step is to contact both the Human Resource Manager and the Programme Chair to make the ideas for a new project known. This is done with the aid of short form. This allows the Human Resource Manager to determine whether the staff member has room within her/his function or career planning for this new project and allows the Programme Chair to determine whether the idea of the staff member fits in the L&C Programme, and whether there is financial/personnel room (Dutch: formatieruimte) within the Programme.

If both the Human Resource Manager and the Programme Chair come to a positive conclusion, the staff member is given a maximum of eight workweeks (excluding holidays, vacations, et cetera) to prepare a project proposal. The norm investment for the preparation of a proposal is 0.2 fte per week for the period of eight weeks. In other words, the staff member at this point has the ‘right’ to invest eight workdays preparing the proposal.

Next, proposals go to the Programme Management Meeting (PMM). In order to be admitted for consideration, the proposal must be submitted to the Programme Chair at least three weeks prior to the meeting in which the proposal would be discussed. Two senior staff members are appointed by the Programme Chair to review the proposal and formulate a pre-advice based upon the criteria for judging project proposals. They can advise to either accept the proposal for discussion in the PMM or to reject the proposal based on non-adherence to the format, or in case the proposal is in other ways sub-standard. Proposals are reviewed with regard to the following topics:

- Scientific criteria
- Importance
- Problem definition
- Originality
- Design and methodology
- Feasibility
- Estimate of staff and material budget
- Relevance
- Strategic importance
- Practical importance

Note that in the evaluation, the weight of these topics varies for research projects, laboratories projects or solution projects. If rejected, the applicant can resubmit the proposal to the next PMM following the same procedure. There is no work time ‘earmarked’ for reparation and resubmission. The Programme Chair makes the ultimate decision with respect to resubmission and admittance to the PMM.
After admission to the PMM, the proposal is assessed with three possible outcomes, namely: A - Suitable for funding; B - Not suitable for funding as is, but improvable; C - Not improvable. The Programme Chair decides whether to approve the project and execute it. Also, the explicit recommendations of the external reviewers will be taken into account.

Before the project can be executed, the Dean - after consultation in the MT - has to give formal permission.

Unforeseen circumstances could necessitate adjustments to the project plan along the way. All staff members are entitled to submit additional requests for the projects they are chairing to the PMM. This only applies to activities that were not accounted for in the original project plan. For example, extra conference visits, extra scientific, technical, and support staff support et cetera. A week before the next PMM is scheduled, these additional requests should be e-mailed to the Programme Chair with a clear argumentation that explains why this request is made. The Programme Chair is responsible for putting it on the agenda. During the PMM, the request is either approved or rejected by the Programme Management. In case of an approval, the Dean, after consultation of the management team, has to give formal permission.

Project Monitoring

The monitoring of each project will be done by the Theme Leaders. The progress of each project will be discussed briefly during each Project Management Meeting. When problems are signalled (e.g., projects that severely overrun their time, conflicts between project members), the Programme Chair decides upon a course of action.

Project Evaluation

The evaluation of each finalised project will be done by the Programme Management. A week before the next PMM is scheduled, the project chair provides the Programme Management with the original project plan, an overview of the output of the project and a brief rationale that explains possible discrepancies between planned outcomes and realised outcomes. When external customers were involved in the project, their satisfaction will be evaluated as well. The responsible Theme Leader will discuss the results of this evaluation with the project chair and the project will be closed.

16. Output Targets

The Programme’s performance is measured with separate indicators for Research, Laboratories (Open Innovation) and Solutions.

Research

Researchers in the L&C Programme will usually be affiliated to the Dutch research school ICO, the ‘Interuniversity Centre for Educational Research’, which is recognised by the Royal Dutch Academy of Sciences. A scientific publication is defined as any publication meeting the requirements for staff member admission to ICO: a) publications in ISI journals, usually those on the Social Science Citation Index (SSCI), b) ICO-recognised journals, and c) English, peer-reviewed books or chapters in books.

ICO membership requires having at least 6 scientific publications in the previous 5 years. Researchers are expected to publish at least 2 out of the required 6 publications as a first author. The aim of this Programme is to publish in ISI-listed journals, preferably with an impact factor >1 and in peer-reviewed reputable books. Publishing in non-ISI-listed journals approved by ICO or in low-profile books is accepted, but not encouraged. For more details on different types of publications and publication policy see the document CELSTEC
Research Publication and Communication Policy 2009-2014. Based on the assumption that most staff members have 0.4 fte of their time available for research, and that they are expected to publish 1.2 publications per year in order to be recognised as an ICO staff member, the target for scientific publications is set at three publications output per year for every full time equivalent (fte) of staff input.

PhD candidates, as opposed to staff members, are expected to produce at least three articles during their candidacy (one per year, excluding their first, more theoretically oriented year) and one doctoral dissertation. Doctoral dissertations do not fall in one of the above categories, but are based on those categories (i.e., chapters are or are based on scientific publications –published, in press, or submitted). However, they do constitute important scientific output for CELSTEC, as the dissertations are considered a show front to the outside world.

**Laboratories**

Quantitative and qualitative targets for open innovation activities are currently under development. Plausible targets are ISI publications, non-ISI-listed publications, professional publications, conference contributions, post-project evaluations of customer satisfaction, etc. Publication of software and specifications (open standards) is also likely to be counted as output. Quality conditions are that the output i) contains code and documentation; ii) is accepted by at least two independent reviewers; iii) is made publicly available through Sourceforge or the like under an appropriate open source (code) and open content (documentation) license. The reviewers determine also the size of the output in terms of article point equivalents (quantitative criterion).

**Solutions**

Performance indicators for Solutions are less standardised, but can be expressed by taking into account the Solutions activities that are listed in the established CELSTEC policy document "OTEC Nieuwe Stijl" (The New OTEC) (OTEC, 2008). According to this policy, Solutions includes the following activities:

**Dissemination:** Propagation of results. This includes network participation (committees, boards), popularisation (presentations, columns, debates, interviews, papers, symposiums), licences and students internships. The L&C group (co-)organises conferences: for example the annual Cognitive Load Theory conference. In 2009 this conference has been held at the Open Universiteit in the Netherlands campus. Furthermore an annual symposium for Dutch and Belgian users of the 4C-ID methodology, held in study centres of the OU. The L&C group also moderates a community of 4C-ID users in Surfnet networking environment. As a part of Solutions, professional publications are encouraged as spin-off of scientific publications. Professional publications concern articles in (Dutch) professional journals (e.g., OnderwijsInnovatie, Examens, Didactief), books for practitioners, and websites.

**Assimilation:** Promotion of external inputs to the Programme. Inviting users of models and theories, to author cases of model appliance is a means to create cooperative validation of models and tools. Examples are the publication by Hoogveld and Steinen (2008) and the casebook on 4C-ID (Hoogveld, Janssen-Noordman, & Van Merriënboer, in preparation). This also includes consultations with external parties, visiting staff from industry and educational institutes. Several requests, from companies such as Hella, Philips, Kluwer, Netherlands Patent Office, Netherlands Defense Academy, and educational institutes such as Fontys Hogescholen, Hogeschool van Utrecht, Hogeschool Edith Stein, Hogeschool InHolland, Regional Vocational Training centres in Heerlen, Tilburg, Ede, Vlissingen demonstrate the L&C group’s active interest for innovation of Education and Training.

**Cooperation:** Creating added value by working together. In the field of lifelong learning, middle vocational training, teacher education and industrial training, CELSTEC meets real opportunities for cooperation. This cooperation can consist of piloting new types of
solutions or of grounding for new research projects. This involves strategic alliances with external partners, joint projects and facility sharing.

**Incubation:** Impulses for entrepreneurship and business development. The business to business contacts with an international editor or with industries allow new lines of thinking and organising training: working with intermediates, who are trained by CELSTEC in needs assessment and quick development of training for urgent training needs in the company or in society. The first experiments for this line of organising training as learner-determined will be organised internally in the Open Universiteit in an innovative plan for organising independent individual training and learning facilities to overcome the financial crisis. The L&C group will actively participate in this by designing educational strategies and learning concepts. This concerns contributions to new products and services.

**Transfer:** Handing over of knowledge and artefacts. Some successful tools, instruments and products will be available, such as: Teleforum, procedures for design, an environment to stimulate and organise peer-feedback, called E-space. This involves courses, workshops and training sessions, innovation consultancy and participation in innovation projects. An open educational resources course on 4C-ID, or on arrangements of tasks, and a course for teachers in facilitation of internet searching skills of their students, design procedures for assessment of competencies will be realised.

Indicators for output will not only consist of numbers of solutions, because the L&C group has no capacity in service for every request, but of positive evaluations of the solutions produces: what is the specific added value of the L&C contribution, which would not have been realised without this contribution. Criteria for evaluation of solutions are developed and applied in solutions trajectories and will be reported internally and externally.

The table below provides an overview of the quantitative output targets of the L&C Programme. The financial target for commercial projects is formulated by CELSTEC management on a yearly basis. For year 1 (2010) the target is set at K€ 220.

**Table 4. Targets**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific staff (fte)</strong></td>
<td>24.2</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Scientific papers</strong></td>
<td>29</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>Professional papers</strong></td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td><strong>PhD theses</strong></td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Conference presentations</strong></td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td><strong>Software products</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Student internships</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Visiting guests</strong></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Joint projects</strong></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Workshops and training</strong></td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

**17. Quality Assurance**

In 2006, the ID-OTEC research program, now part of the L&C Programme has had its quality assessed. The protocol used for this is the so-called Standard Evaluation Protocol, published by among others the Dutch Royal Academy of Sciences. It aims to improve the quality of research and to make research organisations more accountable for the way they spend public funds. It consists of a self-evaluation every three years and an external evaluation once every six years. The same periodicity is followed by this Programme, which also lasts
for six years. The research evaluation and Programme life are phase-shifted by two years, with the previous external research evaluation having taken place in 2006 and the next self-evaluation due in 2009. This is not seen as a serious drawback as, this way, it can be avoided that a new programme comes up for evaluation. The main assessment criteria used in the evaluation are

- Quality (international recognition and innovative potential)
- Productivity (scientific output)
- Relevance (scientific and socio-economic impact)
- Vitality and feasibility (flexibility, management, and leadership).

Quoting the protocol (pp 9-11): ‘Quality is to be seen as a measure of excellence and excitement. It refers to the eminence of a group’s research activities, its abilities to perform at the highest level and its achievements in the international scientific community. It rests on the proficiency and rigour of research concepts and conduct; it shows in the success of the group at the forefront of scientific development. Productivity refers to the total output of the group; that is, the variegated ways in which results of research and knowledge development are publicised. Usually, quantitative indicators measure this. In most cases this will be bibliometrics, which are indicators concerned with publications and citations of publications. Relevance is a criterion that covers both the scientific and the technical and socio-economic impact of the work. Here in particular research choices are assessed in relation to developments in the international scientific community or, in the case of technical and socio-economic impact, in relation to important developments or questions in society at large. Vitality and feasibility refers to the internal and external dynamics of the group in relation to the choices made and the success rate of projects. On the one hand, this criterion measures the flexibility of a group, which appears in its ability to close research lines that have no future and to initiate new venture projects. On the other hand, it measures the capacity of the management to run projects in a professional way. Assessment of policy decisions is at stake, as well as assessment of project management, including cost-benefit analysis.

In 2006 an external evaluation was conducted on the then Instructional Design Programme (Instructional Design for Open Tasks, Environments and Communities), covering the years 2002-2005. The Programme participated in the (external) Research Assessment Pedagogics and Education Science 2002-2005.

The committee’s assessment of the Programme was very positive, leading to qualifications of excellent on the criteria quality and viability, and very good on the criteria productivity and relevance.

**External Quality Control**

Two external reviewers comment on each project proposal that is submitted. This helps assure quality and external validation of projects preceding the execution. In addition to this, external validation occurs via:

- Scientific output in acknowledged scientific journals with a peer review system included in the Social Science Citation Index (SSCI), Science Citation Index (SCI), or in other ICO-accepted journals
- Output in journals on educational practice (Dutch: vaktijdschriften)
- Contributions to conferences
- Use of CELSTEC results, techniques and instruments by others
- Contracts and external funding for research.
- Choice of external members in manuscript and promotion committees for PhD theses
- Participation in research elsewhere.
Internal Quality Control

The internal quality assurance concerns all phases in the research cycle, from preparation of proposals through translation of results into guidelines and design recommendations. Generally, three phases are distinguished wherein quality assurance is necessary:

- **Input.** All project proposals are discussed and commented upon in the regular meeting of the Programme Management Meeting. Where necessary, the proposals are revised before the Programme Chair approves the proposal. The Programme Chair monitors the scientific level of the discussions and determines whether the commentary is of sufficient quality. Too much subjectivity, lack of good-fellowship, and plagiarism of ideas and documents have to be avoided. In cases where the priority of proposals is an issue, the Programme Chair can choose to discuss this in PMM, but the integral responsibility for research and research policy is in the hands of the Programme Chair.

- **Throughput.** The project chairs are responsible for the progress of the projects. They consult with the Theme Leader on the progress of their project(s) on a regular basis in Theme meetings and in bilateral discussions. CELSTEC has a system for time registration (called OUPas) that is part of the quality control.

- **Output.** Internal peer review of drafts of articles is encouraged. This peer review, primarily by the more experienced researchers can help assure that the proposed articles meet the accepted criteria for scientific publications. This is also true for design guidelines and recommendations which can be submitted to experienced educational designers, to help assure that the research results meaningfully contribute to the intended educational system.

18. Guaranteeing Relevance over Time

The quality control mechanisms discussed in the previous paragraph provide a powerful incentive to guarantee relevance and validity of the Programme. Every three years, a self-organised midterm review will be conducted to see which adjustments are needed. However, a three-yearly interval may last too long for the Programme to remain relevant and on top of new developments. Besides, not only external drivers may make the plan (in part) obsolete, internally generated changes of conviction, ensuing from the Programmes’ own research efforts, will do so too. Therefore, on a yearly basis, the programme plan and the associated more detailed theme plans will be evaluated. Although the programme plan will remain unchanged, the theme plans may be changed, as they have a runtime of two years, which enables flexibility to adapt to developments in the scientific and societal fields. Following the programme plan’s formal acceptance, the theme activity plans will be developed. They are not project plans in the ordinary sense of the word, with milestones, deliverables and resource allocations. Rather, they describe the suite of project-based activities that can and should be carried out under the flag of the theme in question. They also provide the common denominator for the staff involved in a theme and thus form the basis for deciding what PhD projects to consider, that is, what external funds for research and development to solicit and what to avoid; and what Open Innovation and Solution projects to start up, that is, what partnerships to invest in and what joint applications for external funds to consider and what to ignore. Every year, each theme’s activity plan will come under scrutiny. Does it still provide an adequate translation of the programme plan’s theme description? Have interesting and important new research and development topics come up, have priorities of funding bodies and partners in society at large changed to the extent that this jeopardises a theme’s ability to find resources for its activities?
19. Risk Assessment

With regard to staffing, there is a small core group of senior staff members for running Solutions projects, guidance of the others, and the acquisition of funding for projects. The acquisition of sufficient high quality staff in the Netherlands is sometimes problematic, because of OU’s location on the periphery of the country though recent vacancies have been well-filled. Acquiring international staff and creating home work facilities are considered as options to reduce this risk.

The distance teaching setting (no campus with students) makes it more difficult to find participants for experiments.

With regard to financing, the Programme is still seen as – too – dependent on direct university funding. Further increasing the amount of external funding, over more different funding agencies to limit the risks (i.e., in addition to NWO more EC-funded projects and contract research), is seen as necessary. The premium that OU will receive for completed PhD projects can be used for establishing a fund for matching external projects that are partially funded. This is expected to increase the future sustainability of the Programme.
20. References


21. Dissertations

The full text of the dissertations can be found at: http://celstec.org/node/179

2009
Sandra Wetzels: Individualised strategies for prior knowledge activation
Fleurie Nievelstein: Learning law: Expertise differences and the effect of instructional support

2008
Amber Walraven: Becoming a critical researcher. Effects of instruction to foster transfer.
Wendy Kicken: Portfolio use in vocational education: Helping students to direct their learning
Anne Helsdingen: Training Complex Judgment: The Effects of Critical Thinking and Contextual Interference
Desirée Joosten-tten Brinke: Assessment of Prior Learning
Gemma Corbalán Pérez: Shared control over task selection: Helping students to select their own learning tasks.

2007
Pieter Wouters: How to optimize cognitive load for learning from animated models.
Karen Könings: Student perspectives on education: implications for instructional redesign
Judith Gulikers: Authenticity is in the eye of the beholder. Beliefs and perceptions of authentic assessment and the influence on student learning
Tamara van Gog: Uncovering the problem-solving process to design effective worked examples

2005
Eddy Boot: Building-block solutions for developing instructional software
Marlies Bitter: Knowledge elicitation support for virtual multi-expertise teams
Ron Salden: Dynamic Task Selection in Aviation Training.
Hans Hummel: Design of Cueing in Multimedia Practicals: Studies into Cueing Formats, Learner Control and Collaboration to Support the Learning of Complex Skills
Angela Stoot: Tools for the identification and description of competencies.

2004
Jan-Willem Strijbos: The effect of roles on computer-supported collaborative learning
Ad Schellekens: Towards flexible programmes in higher professional education
Karel Kreijns: Sociable CSCL Environments: Social Affordances, Sociability and Social Presence
Rob Nadolski: Process Support for Learning Tasks in Multimedia Practicals

2003
Liesbeth Kester: Timing of Information Presentation and the Acquisition of Complex Skills
Jan van Bruggen: Explorations in graphical argumentation. The use of external representations in collaborative problem solving.
Bert Hoogveld: The teacher as designer of competency-based education

2002
Frans Prins: Search & see: the roles of metacognitive skillfulness and intellectual ability during novice inductive learning in a complex computer-simulated environment.
Huib Tabbers: The modality of text in multimedia instructions. Refining the design guidelines.
Dominique Sluijsmans: Student involvement in assessment. The training of peer assessment skills