Supporting life-long competence development using the TENCompetence infrastructure

Document status and date:
Published: 01/07/2008

Document Version:
Publisher's PDF, also known as Version of record

Document license:
CC BY-NC-ND

Open Universiteit
www.ou.nl

Supporting Life-Long Competence Development Using the TENCompetence Infrastructure: A First Experiment

J. Schoonenboom[1], H. Sligte[1], A. Moghnieh[2], D. Hernández-Leo[2], K. Stefanov[3], C. Glahn[4], M. Specht[4] and R. Lemmers[5]

[1] University of Amsterdam, Amsterdam, The Netherlands
[2] Universitat Pompeu Fabra, Barcelona, Spain
[3] University of Sofia "St. Kliment Ohridski", Sofia, Bulgaria
[4] Open University of the Netherlands, Heerlen, The Netherlands
[5] Logica Nederland B.V., Maastricht, The Netherlands

Abstract—This paper describes an experiment to explore the effects of the TENCompetence infrastructure for supporting lifelong competence development which is now in development. This infrastructure provides structured, multi-leveled access to learning materials, based upon competences. People can follow their own learning path, supported by a listing of competences and their components, by competence development plans attached to competences and by the possibility to mark elements as complete. We expected the PCM to have an effect on (1) control of participants of their own learning, and (2) appreciation of their learning route, (3) of the learning resources, (4) of their competence development, and (5) of the possibilities of collaboration. In the experiment, 44 Bulgarian teachers followed a distance learning course on a specific teaching methodology for six weeks. Part of them used the TENCompetence infrastructure, part used an infrastructure which was similar, except for the characterizing elements mentioned above. The results showed that in the experimental condition, more people passed the final competence assessment, and people felt more in control of their own learning. No differences between the two groups were found on the amount and appreciation of collaboration and on further measures of competence development.

Index Terms—lifelong learning, competence development, infrastructure, evaluation

I. INTRODUCTION

The emerging knowledge society places new demands on both individual workers, groups, and organizations. Central to these demands is the need to continuously develop and manage the competencies which provide competitive advantages [1].

To achieve lifelong competence development there is a need for better integration of learning and knowledge dissemination facilities offered by the different knowledge support organizations in society, e.g. educational institutes, training departments, HRM support organizations, government, libraries, research institutes and others.

The requirements placed on the models and technologies to support such integrated facilities differ considerably from those traditionally placed on technologies to support particular fragments of a learning lifetime, or to serve the knowledge dissemination and knowledge management needs of a company.

The TENCompetence project is a four-year project in the European Commission's 6th Framework Programme, priority IST/Technology Enhanced Learning. The aim of the project is to design a technical and organizational infrastructure for lifelong competence development. The project develops new innovative pedagogical approaches, assessment models and organizational models, and it creates a technical and organizational infrastructure which integrates existing isolated models and tools for competence development into a common framework [2].

In June 2007, a first version of the infrastructure was delivered, consisting of the TENCompetence server and a client software package, called the 'Personal Competence Manager' or PCM for short [3].

Basically, the PCM allows providers of life-long competence development to give structured, multi-leveled access to learning materials, based upon competences, and it allows users at each level to discuss and provide comments (see Figure 1 and 2).
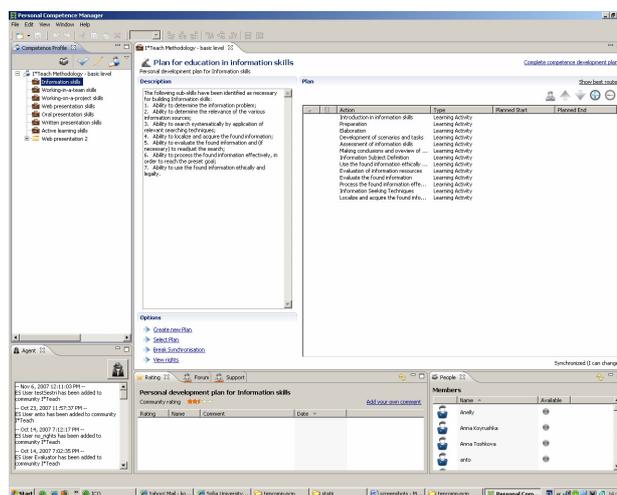

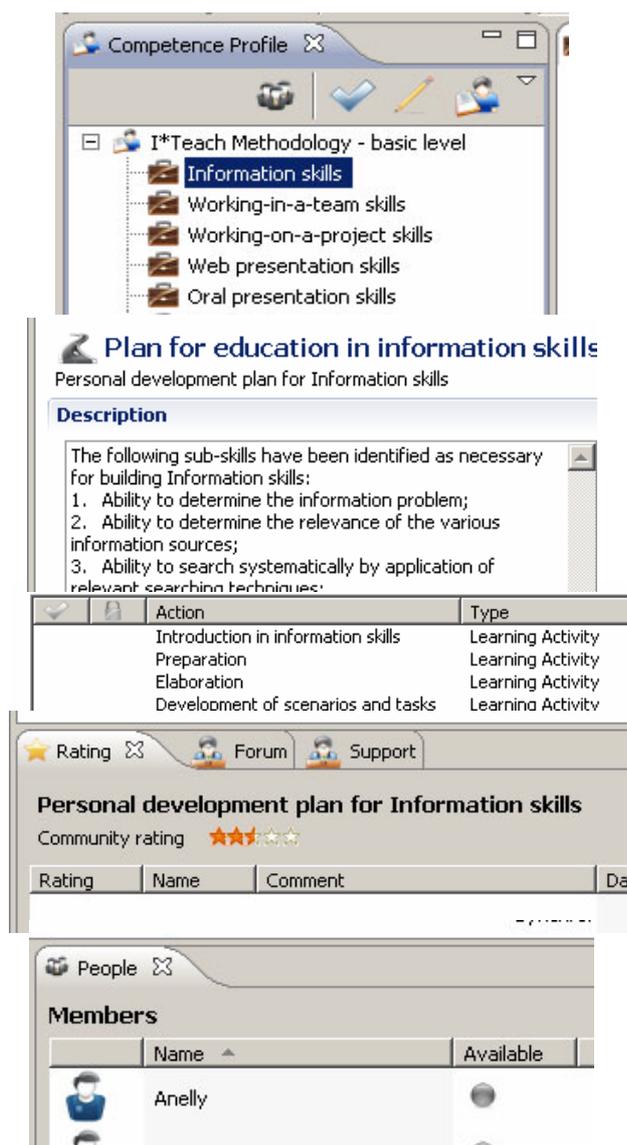Figure 1.   Overview of the PCM as used in the pilot

Figure 2. Elements of the PCM, from top to bottom: competence profile, description of competence development plan, list of actions, rating, forum and support tabs, people tab with underlying chat functionality

The TENCompetence infrastructure will be validated in a number of different pilots, representing the variety of contexts in which lifelong competence development takes place [4]. This paper presents the results of one of the pilots, a pilot in Bulgaria for teachers who have to update their skills in using ICT in teaching, called the 'ICT Teacher Training pilot' [5, 6, 7].

In our research we performed an experiment to explore (1) the effects that using the PCM had on the participants of the pilot, and (2) the relations between these effects and the elements of the infrastructure as they were used by the participants.

Our paper is organized as follows. In Section II we provide the rationale for our approach. Section III provides a detailed description of the PCM. Section IV describes our underlying 'program theory' about how use of the PCM may have particular effects. As context has a large influence on how people use the PCM, section V provides a detailed description of the context in which the pilot with

the PCM was set up. In section VI through VIII, our exploration of our program theory is described. Section VI describes the experiment, in which we explored the effects of the use of the PCM. Section VII examines which elements of the PCM were actually implemented and used. In section VIII we show what we did to rule out alternative explanations. Finally, section IX contains the discussion.

II. RATIONALE FOR OUR APPROACH

The validation of the TENCompetence infrastructure can be seen as a special form of program evaluation [8], in which a program is defined as an "organized effort to enhance human well-being" [9]. The basic aim of program evaluation is to establish the effects and working of the program, rather than testing one specific hypothesis. Program evaluators always have to deal with a multitude of possible effects and a multitude of possible causes of these effects, which occur in a specific context. To the extent that they try to link effects to causes, they are concerned with the 'program theory', the theory of how the program works.

Usually program evaluation is applied to 'social interventions', such as programs for the reduction of drug abuse or educational programs in which class size is reduced. Applying this type of evaluation to the evaluation of technical systems means moving evaluation of these technical systems beyond usability testing. Program evaluation's main aim is not to test the usability, but to investigate how people in actual practice work with the technology as it is and what effects this has on them.

We had several reasons to perform an experiment. Many factors may influence competence development, and we used the experiment to find out which of these are likely candidates for further exploration. We deliberately set up an experiment in which the treatment for the experimental and control group was not very different. In fact, the groups differed only with respect to the factors that we wanted to explore. Such a set-up runs a high risk of finding no differences [10]. But if one then, despite the similarity of the treatments, does find differences between experimental and control group, this provides very strong support for the generation of a hypothesis that is likely to have an effect.

Although often experiments, and sometimes also quantitative research as a whole, are seen as related to the confirmatory phase of research, based upon firm hypotheses, this needn't be the case. Firstly, randomized experiments do not need a good theory of the program and its mediating processes, in order to be able to detect an effect of the intervention: establishing differences between the group that receives the treatment and a control group suffices [11]. Secondly, within experiments an 'internal analysis' can be used for generating hypotheses [10]. In an internal analysis one tries to find correlations between aspects of the treatment and aspects of the outcomes. This is what we did. Finally, theory-based program evaluation can be combined with experiments for comparison [12].

III. THE PERSONAL COMPETENCE MANAGER

The Personal Competence Manager (PCM) provides hierarchically structured access to resources, based upon competences. A competence profile (Figure 2) lists the competences that have to be acquired for the successful fulfilment of a specific role, which might range from the

very formal to the very informal. With each competence in the competence profile, one or more competence development plans can be associated, which is a plan through which that competence can be acquired. A competence development plan consists of several actions, learning activities that can be performed by the learner. Within each learning activity, resources can be listed by including a link to the URL of the resource.

Different from other learning environments, each element of the PCM has its own collaboration facilities attached to it. Thus each competence profile, each competence development plan, each action and each resource has its own forum and its own chat facility. Furthermore a rating possibility is attached to each element, through which learners can indicate their appreciation of the element, using a five star coding. Finally, each element can be marked as attained or completed, thereby giving the learner an overview of how far they have progressed.

IV. THE PROGRAM THEORY

Our evaluation can be considered a theory-driven evaluation [13, 14]. Our focus is on the 'program theory' [14], which describes how the intervention is supposed to work, what effects and possible causes are present and how they are related.

The TENCompetence project proposal [15] describes the approach towards learning with technology that is to be implemented in the PCM. The aim is more self-directed learning, which integrates formal and informal learning activities. The project proposal links this aim to social-constructivist principles of learning, and it mentions collaborative learning, use of learning communities, authentic tasks, scaffolding, new assessment methods, and legitimate peripheral participation. Although not explicitly mentioned, there is a strong link to adult learning, and to the need for adults to engage in self-directed learning, based upon their own learning needs [16]. The third pillar of the project is new Internet technologies, which can support self-directed, mobile, integrated formal and informal learning, which can support collaborative problem-solving and the sharing of knowledge and views.

Thus the PCM is intended to be used by learners who are allowed to take their own route and to make their own selection of elements, best fitting their learning needs. In this sense, the PCM offers an infrastructure [2, 3] which, as far as the learner's freedom is concerned, occupies a position halfway in between traditional education with its rigid learning paths and on the other hand communities such as Flickr and YouTube [17], which provide access to many resources, but do not provide a learning path.

The project proposal does not come with a full-blown theory of how the infrastructure to be developed will support learning, i.e. how the functionalities of the PCM will lead to better learning. But based partly on general usability principles, partly on common sense, we expect the use of the PCM to influence factors that are known from earlier research to have a beneficial effect on learning: the amount of control learners experience over their learning [18], motivation [19], collaboration [20, 21].

The aim of the research reported in this paper is to generate one or more hypotheses for further research, supported by our data. We base our explorative study on five effects that we expect to occur, based on our program theory:

(1) We expect learners to feel in control of their learning. Three characteristics of typical PCM use are expected to contribute to this feeling: (a) the possibility for people to choose their own resources and learning routes will enable people to select only those resources that are relevant to their learning process, and thus will make learning more efficient. (b) structured access based on competences will provide people with an overview that enables them to quickly access competences, competence development plans, actions and resources that are relevant to their learning; (c) learners can mark elements as completed or attained; this will give learners an overview of what they have already done or acquired, so that they can skip these elements.

(2) We expect learners to appreciate their learning route. This is related to the fact that with typical PCM use, learners can choose their own learning route, and we expect that learners then will choose a learning route that best fits their way of learning.

(3) Similarly, we expect learners to appreciate the learning resources. This is related to the fact that with typical PCM use, learners can choose their own learning resources, and we expect that learners will choose those resources that best match their learning needs.

(4) We expect that collaboration is fostered by the fact that collaboration facilities, such as chat, forum and rating, are attached to the elements they belong to, rather than brought together into one chat facility or one forum.

(5) We expect that all these elements together will foster competence development.

V. THE CONTEXT

Since the context has a large influence on the effects of the program, a detailed description of the context was needed. We used two strategies. First, we asked the pilot coordinator for a detailed description of the pilot. Second, we asked participants for their background characteristics. Participants filled in a pre-test questionnaire in which they provided information on their background, level of competence development, experience with web-based learning, motivation, involvement of their employer, learning style and technical facilities.

A. Pilot description

The ICT Teacher Training pilot was performed in Bulgaria in the autumn of 2007, it lasted for one month and a half with a working load of 100 hours in total, including the assessment.

The objective of the pilot was that participants became acquainted with the I*Teach Methodology [6, 22], a specific pedagogical approach with an emphasis on collaborative learning. During the first face-to-face starting workshop, first both groups were introduced to the I*Teach Methodology at large, then to their respective software tool (Moodle for the control group, PCM for the experimental group). After that all teachers in the both groups were invited to form groups (2-3 participants in a group), to choose a project (with general objective: applying I*Teach methodology in the process of teaching in their own specialty), to start to work on a project and to have the first feedback.

After this workshop both teachers from both groups were involved in the developing of their specific project, using the facilities of the respective software for commu-

nication and collaboration, and during the final workshop they presented their project to all other teachers.

B. Participant characteristics

44 participants participated in the pilot, 37 women and 7 men. All came from Bulgaria. Most of them were middle-aged. The youngest participant was 23 years old and the oldest participant was 57 years old. In general the participants were highly educated. A large majority had a university master's degree (N=38), 5 participants had a bachelor degree and 1 participant had a degree in secondary vocational education.

Most of the participants worked as a teacher (N=40, including 5 IT teachers). Three participants were school directors and one participant was a university lecturer. Years of experience in their profession ranged from 0 to 31 years.

Their own proficiency level with respect to the teaching competence was rated by almost all participants as either intermediate (N=21) or advanced (N=17).

To most participants, following a course through distance learning is a new experience. The large majority has not followed any course or module through distance learning (N=34).

The use of search functions such as Google was most familiar. Almost everyone used search often very often. With respect to the sharing of data in online communities, both for professional and leisure purpose, a large majority of 31 participants used it often or very often, but here there was a larger spread. Ratings are used slightly less, with answers being equally divided between sometimes (N=14), often (N=16) or very often (N=12). There are large differences in how often participants use chat, with all options having a reasonable share. The least used option is online discussion forums, which almost all participants use never (N=18), occasionally (N=11) or sometimes (N=10).

For a large majority of the participants involved, their motivation is related to job or proficiency improvement: they wish to keep up to date within their existing function or job (N=36), they with to improve their proficiency level of a specific competence (N=31) or they wish to study for a new function or job or improve their current job level (N=27). Only a minority of participants wish to define new learning goals for themselves, rather by reflecting on their current competences (N=17) or by exploring the possibilities in a new field (N=15). Only 11 participants look for support on a non-trivial learning problem.

For almost all participants, their employer is not involved in their following the ICT Training pilot (N=40).

Most participants (N=26) would prefer that a learning path is laid out that they have to follow. Of the remaining participants, half prefer to have the resources only and half prefer to be able to choose either their own learning path or follow a prepared path.

The large majority of participants have a computer which is neither new nor old (N=36). There are more differences with respect to the internet connection. Most participants have a fast (N=25) or very fast (N=3) connection, yet 6 participants have a slow connection and 10 participants have a connection of medium speed.

VI. ESTABLISHING THE EFFECTS

A. Methodology

1) Set-up of the experiment

Our program theory mentions five characteristics of typical use of the PCM that are expected to have an effect on competence development: (1) choice for own learning resources (2) choice for own learning routes, (3) structured access based on competences, (4) marking of elements as completed, (5) attachment of collaboration facilities, such as chat, forum and rating to the elements to which they belong.

In order to test the effects of these five characteristics, we designed an experiment with two conditions in which learning goals, objectives, learning content and time schedule were the same, but the approach was different. Therefore we created an alternative learning environment in Moodle, in which the five characteristics of the PCM had the opposite value. Thus, for the participants assigned to the Moodle condition, the learning materials were ordered in lessons to be followed in a specific order, not in competences. Participants in the Moodle condition could not mark elements as completed, and chat and forum were not attached to specific elements; rating was not present. For the rest, the conditions were identical.

In the experiment, the intention was to assign participants randomly to conditions, but this turned out to be impossible. At a very late stage in designing the pilots, it became clear that there would be two separate groups of teachers, who would work together and would start one week after the other. No other measures could be taken, so that effectively the experiment became a quasi-experiment. As a result, there was also a difference in group size between the experimental and control group. We performed an additional test to rule out alternative explanations, which is described in section VIII below.

A total of 45 participants attended the ICT Training pilot. Of these participants, 44 were included in the analyses. The reason for excluding one of the participants was that this participant had spent 7 hours on the pilot, whereas the other participants spent between 36 and 60 hours. Therefore the results of this participant would not be comparable to the other participants. 19 of the participants worked in the experimental condition, using the PCM system and 25 participants worked in the control condition, using the Moodle system.

2) Measures

As stated in section IV, we expected the PCM to have an effect on (a) control of participants of their own learning (b) appreciation of their learning route (c) appreciation of the learning resources (d) competence development (e) collaboration. These five variables were measured as scores on a post-test questionnaire which was given to participants in both conditions. They were operationalized as follows. After each scale name, Cronbach's α is provided, based on standardized items.

Control of their own learning

Mean score on a scale Appreciation of control (.79) composed of answers to the following six items: (1) agree completely…… (5) disagree completely:

- In the beginning, I quickly got an overview of the competences involved and my current proficiency level

- I had a good overview on what I had done and what I had to do
- I had insight into how my learning progressed
- I had the feeling that I learned exactly what I wanted to learn
- I had the feeling that I could plan my own learning
- I felt in control of my own learning

Appreciation of learning route

Mean score on a scale Appreciation of learning route (.70) composed of answers to the following two items:

- The learning route I followed was (1) very efficient …… (5) very inefficient
- The learning route I followed was (1) very exciting …… (5) very boring

Appreciation of learning resources

Mean score on a scale *Appreciation of learning resources* (.78) composed of answers to the following three items:

- The learning resources were (1) very interesting…… (5) very uninteresting
- The learning resources were (1) very useful…… (5) very useless
- The learning resources matched my learning needs (1) completely………(5) not at all

Competence development

Answer to the question: did you pass the final competence assessment? Yes / No

Collaboration

Mean score on a scale Appreciation of collaboration (.77) composed of answers to the following three items: (1) agree completely…… (5) disagree completely

- In our small group we had a lively and stimulating discussion
- In our small group we had a lively and stimulating exchange of data and files
- In the larger group of all people following this course, we had a lively and stimulating discussion

Note: the item 'in the larger group of all people following this course, we had a lively and stimulating exchange of data and files' was excluded from the scale because of a too low item-rest correlation.

Separate scores on the following items:

Number of messages posted to forum:

- How many messages did you post to the forum (approximately)? ___

Overall rating of forum:

- What is your overall rating of the forum? (1) very useful…… (5) very useless

Number of times chat used:

- How many times did you use the chat (approximately)? ___

Overall rating of chat:

- What is your overall rating of the chat? (1) very useful…… (5) very useless

3) Analysis

Differences between groups on the scales and items were analysed using a one-way ANOVA. As ten tests were performed, the significance level for each test was set to .005 [23].

As passing the competence assessment was a dichotomous variable, the differences between groups on this variable were analyzed using a Chi-square test.

B. Results

In general, there were no differences between the two conditions. Only two results reached the preset significance level. First, in the experimental condition, more participants passed the final competence assessment ($\chi2$ = 8,68, df=1, p = .003). Second, in the experimental condition, participants felt more in control of their own learning (F=9,91, df = 1, p = .003).

VII. USE OF PCM ELEMENTS

A. Methodology

This section examines which elements of the PCM were actually implemented and used, so that they might have had an influence on the effects in the last section. To this end, we set up a post-test questionnaire, asking participants for their use of the PCM functionalities. This questionnaire contained the following items:

Use of chat, forum, ratings

- How many messages did you post to the forum (approximately)?
- How many times did you use the PCM chat (approximately)?
- Did you look at ratings provided by others? Yes / No
- How many times did you provide ratings yourself to a learning element?

Choose own resources

- In general, did you work through all competences, actions, resources that were presented in an existing competence profile? Didn't use existing / yes / no

Choose own learning routes

- In general, did you work through competences, actions and resources in the order in an existing competence profile in which they were presented? Yes / No

Use of marking elements as complete

- Did you make use of the possibility to mark learning elements as complete? Yes / No

B. Results

Of the 19 PCM participants, 11 indicated that they did not use the forum at all. Two participants posted one message to the forum, three participants posted two messages and another three participants posted three messages to the forum.

Half (10 of the 19) PCM participants didn't use the chat at all. Of the participants using chat, two participants used it twice, two participants used it three times, and one participant used it six times.

Of the 19 participants, 11 indicated that they didn't look at ratings provided by others. Two participants provided one rating themselves and three participants provided two ratings.

Around half of the participants made their own selection (N=12). Ten participants in general chose their own order of elements.

Only one third (N=6) made use of the option to mark elements as attained or completed.

VIII. RULING OUT ALTERNATIVES

As explained in section VI, randomization turned out not to be possible. To exclude the most likely alternative explanations for the effects, we compared the participants in the two conditions on their background characteristics, using the questionnaire described in Section V. We found no significant differences in background between the participants in the experimental and the control condition.

IX. DISCUSSION

From the experiment it became clear that more participants in the PCM condition passed the competence assessment, and participants in the PCM condition felt more in control of their own learning. This lends support to our fifth expectation of our program theory, that all elements of the PCM together will foster competence development.

Furthermore, participants felt more in control of their own learning. Of the three elements that are expected to contribute to this, marking elements as completed can be ruled out, as this was hardly done. The most important factor that contributed to this effect will have been the hierarchical structure of the PCM, which was used by all participants. Half of the participants chose their own learning route and learning resources, so for these participants this may have contributed to their feeling in control of their own learning.

We found no effect of the PCM on collaboration. This is not surprising, as the collaboration facilities were hardly used. Half of the participants made use of the forum, chat, and rating, but only a very limited number of messages and ratings were posted.

Finally, no effect was found on the appreciation of the learning route and learning resources. As half of the participants used the possibility to choose their own learning pathway and/or resources, we would have expected that an effect would have occurred. More research is needed to further investigate this issue.

Undoubtedly, these results are influenced by characteristics of the participants. The pilot participants were highly educated middle-aged teachers, who in general were more used to using the internet for searching for information that for discussion and data sharing. Although not sent or obliged by their employers, their motivation was job improvement and improvement of their proficiency level, and not defining learning goals for themselves. Outcomes may well be substantially different for different target groups.

REFERENCES

[1] E. J. R. Koper, *Building Learning Networks for Lifelong Learning* [keynote at the 23rd dies natalis of the Open University of the Netherlands, 28 September 2007]. Heerlen: Open University of the Netherlands, 2007.

[2] *TENCompetence project*. Website, retrieved February 2008 from http://www.tencompetence.org.

[3] C. Kew, "The TENCompetence Personal Competence Manager", 2nd European Conference on Technology Enanced Learning, *CEUR Workshop Proceedings, online CEUR-WS.org/Vol-280*, Crete, Greece, 2007.

[4] J. Schoonenboom, H. Sligte, A. Moghnieh, M. Specht, C. Glahn, and K. Stefanov, "Pilot evaluation in TENCompetence: a theory-driven model", TENCompetence Open Workshop, Barcelona, Spain, in *Current Research on IMS Learning Design and Lifelong Competence Development Infrastructure, Proceedings of the 3rd TENCompetence Open Workshop*, T. Navarette, J. Blat and R. Koper, Eds., Barcelona, Spain, 2007, pp. 43-50.

[5] Working group "ICT in education and training" of the European Commission, *Implementation of "education & training 2010" work programme,* progress report November 2003. Retrieved February 2008 from http://ec.europa.eu/education/policies/2010/doc/it-technologies_en.pdf.

[6] *I*Teach, methodological handbook on ICT-enhanced skills*. Sofia, Bulgaria: Faleza-office 2000, 2007.

[7] K. Stefanov, I. Naskinova, and R. Nikolov, "ICT-enhanced Teacher training for Lifelong Competence Development", *Proceedings of the IFIP IMICT 2007 Conference, Boston, USA, June 2007*. Available from http://dspace.ou.nl/handle/1820/973.

[8] D. L. Stufflebeam and A. J. Shinkfield, *Evaluation theory, models, and applications*. San Francisco: Jossey-Bass, 2007.

[9] H.-T. Chen, *Practical program evaluation: assessing and improving planning, implementation, and effectiveness*. Thousand Oaks: SAGE, 2005.

[10] R. F. Boruch, "Randomized field trials in education", in *International handbook of educational evaluation*, T. Kellaghan, D. L. Stufflebeam, and L. A. Wingate, Eds. Dordrecht: Kluwer, 2003, pp. 107-124.

[11] T. D. Cook and M. R. Payne, "Objecting to the objections to using random assignment in educational research", in *Evidence matters: randomized trials in education research*, F. Mosteller and R. F. Boruch, Eds. Washington, DC: Brookings Institution Press, 2002, pp. 150-178.

[12] C. H. Weiss, "What to do until the random assigner comes", in *Evidence matters: randomized trials in education research*, F. Mosteller and R. F. Boruch, Eds. Washington, DC: Brookings Institution Press, 2002, pp. 198-224.

[13] H.-T. Chen and P. H. Rossi, *Using theory to improve program and policy evaluations*, Contributions in political science, vol. 290. London : Greenwood Press, 1992.

[14] C. H. Weiss, "How Can Theory-Based Evalutation Make Greater Headway?" *Evaluation review*, vol. 21, pp. 501-524, 1997.

[15] E. J. R. Koper, *Building The European Network for Lifelong Competence Development*, proposal for the Integrated Project TENCompetence. Submitted to the European Commission on 22 March 2005.

[16] M. S. Knowles, E. F. Holton III, and R. A. Swanson, *The adult learner: the definitive classic in adult education and human resource development*. Amsterdam: Elsevier, 2005.

[17] P. Anderson, *What is Web 2.0? Ideas, technologies and implications for education*, JISC Technology and Standards watch, 2007. Retrieved February 2008 from http://www.jisc.ac.uk/media/documents/techwatch/tsw0701b.pdf.

[18] R. M. Ryan and E. L. Deci, "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being," *The American psychologist*, vol. 55, pp. 68-78, 2000.

[19] P. R. Pintrich and D. H. Schunk, *Motivation in education: theory, research, and applications*. Englewood Cliffs, NJ: Merrill, 1996.

[20] M. Baker and K. Lund, "Promoting reflective interactions in a CSCL environment," *Journal of computer assisted learning*, vol. 13, pp. 175-193, 1997.

[21] N. M. Webb and S. Farivar, "Developing productive group interaction in middle school mathematics," in *Cognitive perspectives on peer learning*, A. M. O'Donnell and A. King, Eds. Mahwah, NJ: Erlbaum, 1999, pp. 117-149.

[22] E. Stefanova, E. Sendova, I. Nikolova, and N. Nikolova, "When I*Teach means I*Learn: developing and implementing an innovative methodology for building ICT-enhanced skills" *Proceedings of the IFIP IMICT 2007 Conference, Boston, USA, June 2007.* Available from http://dspace.ou.nl/handle/1820/1065

[23] R. P. Abelson, *Statistics as principled argument*. Hillsdale, N.J.: L. Erlbaum Associates, 1995.

AUTHORS

J. Schoonenboom is with the SCO-Kohnstamm Institute, University of Amsterdam, Amsterdam, The Netherlands (e-mail j.i.schoonenboom@uva.nl).

H. Sligte is with the SCO-Kohnstamm Institute, University of Amsterdam, Amsterdam, The Netherlands (e-mail h.w.sligte@uva.nl).

A. Moghnieh is with the Universitat Pompeu Fabra, Information and Communication Technologies Department, Barcelona, Spain (e-mail ayman.moghnieh@upf.edu).

D. Hernández-Leo is with the Universitat Pompeu Fabra, Information and Communication Technologies Department, Barcelona, Spain (e-mail davinia.hernandez@upf.edu).

K. Stefanov is with the University of Sofia "St. Kliment Ohridski", Faculty of Math and Informatics, Sofia, Bulgaria (e-mail krassen@fmi.uni-sofia.bg).

C. Glahn is with the Open University of the Netherlands, Educational technology expertise centre, Heerlen, The Netherlands (e-mail christian.glahn@ou.nl).

M. Specht is with the Open University of the Netherlands, Educational technology expertise centre, Heerlen, The Netherlands (e-mail marcus.specht@ou.nl).

R. Lemmers is with Logica Nederland B.V., Maastricht, The Netherlands (e-mail ruud.lemmers@logica.com.