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## Final report on the STELLAR Delphi study

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# D1.6

## **Final report on the STELLAR Delphi study**

Future directions for TEL and  
TEL research: Areas of Tension,  
Core Research Areas, and Grand  
Challenge Problems

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Edited by

Hans Spada, Christine Plesch,  
and Michael Wiedmann

**STELLAR**



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# Final report on the STELLAR Delphi study

Future directions for TEL and TEL research: Areas of Tension  
and Core Research Areas

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# Executive Summary

In this report on the STELLAR Delphi study, we present the results of the final global survey, that is the 4<sup>th</sup> STELLAR Delphi round, and illustrate the elaboration and dissemination of these results (5<sup>th</sup> STELLAR Delphi round). The deliverables D1.3 and D1.3A provided detailed information about the preceding STELLAR Delphi rounds (1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> STELLAR Delphi rounds).

The STELLAR Delphi study aimed at identifying future research themes and areas of tension for technology-enhanced learning (TEL) and explored opinions and visions held by European and global TEL stakeholders and researchers. The STELLAR Delphi study was composed of five rounds.

The questionnaire of the 4<sup>th</sup> STELLAR Delphi round presented the consolidated and elaborated results of the three preceding Delphi rounds – 11 Core Research Areas and 5 Areas of Tension – to 569 international experts. The first part of the questionnaire addressed the Areas of Tension:

- The first Area of Tension contrasts the benefits of personalized learning environments through data tracking with the possible misuse of personal data such as a person's learning history.
- In the second Area of Tension, social inequities within TEL, named digital divide, are discussed. It raises the question whether the observed technology spread will really help to overcome the digital divide in the future.
- The third Area of Tension contrasts the advantages of TEL anywhere at any time with the need for focused and critical processing of information.
- In the fourth Area of Tension the reliance on approved school practices is opposed to the immediate adoption of innovative technology in the classroom.
- The fifth Area of Tension weighs up individualization against standardization of learning profiles, taking into account the issues of assessment, accreditation, better comparison of degrees, and mutually shared knowledge within a society.

Overall, the international experts identified themselves more with positions that emphasized the benefit of TEL in opposition to the positions that focused on potentially arising issues when implementing technologies in educational settings. This finding may reveal a blind spot in experts' views on issues of implementation of TEL in the classroom and could also help to explain why the translation of research findings into educational practices falls short of expectations, despite progress in the research field of TEL.

While the experts overall focused on the benefits of technologies, when their attention was drawn to the underlying tensions described in the AoTs, the experts did recognize that these are significant issues impacting the wider implementation of TEL. Indeed, the experts expected the strength of AoT1 *data privacy vs.*

*personalized learning* to increase over the next ten years, while being optimistic that overall the tensions could be reduced in the future. However, this will require an awareness of the issues represented in the AoTs and, consequentially, taking influence on their development.

The second part of the 4<sup>th</sup> STELLAR Delphi round questionnaire was about the Core Research Areas. We asked the experts to rank the 11 Core Research Areas according to their importance for future research programs in TEL. The experts of the 4<sup>th</sup> Delphi round revealed the following order:

1. *Connection between formal and informal learning*, 2. *Computer-supported collaborative learning*, 3. *Personalized learning*, 4. *Contextualized learning*, 5. *Ubiquitous & mobile technology/learning*, 6. *Improve practices of formal education*, 7. *Emotional and motivational aspects of learning*, 8. *Informal learning*, 9. *Reducing the digital divide*, 10. *Workplace learning*, 11. *Interoperability*.

After having ranked the Core Research Areas, the experts were asked to choose one Core Research Area and to sketch a project proposal for a future research projects in this area. These 311 project proposals, many of which are innovative, interesting and thought provoking, underpin the rank order with concrete research projects. They address research questions in the field of TEL that allow for Grand Challenge Problems to be identified. This report presents five Grand Challenge Problems for TEL research that have already been developed (*CSCL in teacher training and professional development; Mobile augmented reality in health care training; Acquisition of graphical and digital literacies through teaching with ICTs; Increasing student motivation to learn and engaging the disengaged; Bridging informal and formal contexts to create a unified learning landscape*).

In addition, the rank order of comprehensive research themes – Core Research Areas – together with the bank of research projects could inspire researchers to submit proposals to funding agencies to support research in these fields in form of national or European priority programs.

The Areas of Tension and Core Research Areas were discussed in various STELLAR activities such as doctoral schools (JTEL winter school 2011) or stakeholder workshops (EDEN 2011). The final TEL Grand Challenge Vision and Strategy Report D1.8 will include the entire set of Grand Challenge Problems that are based on the Delphi results.

# 1 Introduction - STELLAR Delphi Study

The STELLAR Delphi Study sought to construct a catalogue of recommendations for future research in technology-enhanced learning (TEL) by involving a global panel of researchers and stakeholders. A common approach for analyzing future visions shared by experts in a given field are foresight studies (Cuhls, Blind, Grupp, & Bradke, 2002). We deliberately chose the Delphi method, a scientific technique for forecasting emerging trends and issues in a given field by exploring experts' opinions on the matter (Gordon & Helmer, 1964; Linstone & Turoff, 1975). Over the past three years, experts participated in an iterative process of generating and refining recommendations regarding two main aspects of the future development in TEL research: Areas of Tension (AoT) that characterize contrary views within the field of TEL that need to be resolved in order to move the field forward, and Core Research Areas (CRA) which are comprehensive research themes that integrate technological developments and societal challenges. This final report gives a short overview of the Delphi study and describes the identification and evaluation of the Areas of Tension, the prioritization of the Core Research Areas, and the development of Grand Challenge Problems.

## **Design of the STELLAR Delphi Study**

The Delphi study has been conducted in five rounds. It consisted of two large global survey-rounds among TEL experts from outside the STELLAR network of excellence (2<sup>nd</sup> and 4<sup>th</sup> Delphi round) and two internal rounds that were conducted within the STELLAR network (1<sup>st</sup> and 3<sup>rd</sup> Delphi round) and the final round for disseminating the results (5<sup>th</sup> Delphi round). The internal rounds served to prepare, analyze, and discuss the external, global surveys and to integrate and distribute the results.

## **Experts of the STELLAR Delphi Study**

Researchers apply variations of the key characteristics of Delphi studies when adjusting the Delphi design to fit their specific research questions (Thompson, 2009). We modified the classical Delphi approach for involving researchers as well as stakeholder in the iterative process of the STELLAR Delphi study. For this purpose, we employed several panels of experts to participate in the Delphi study. The experts remained anonymous and only after completion of the Delphi round, the names were revealed (Rowe & Wright, 1999, see Appendix B). In the following, we shortly describe the different panels of experts.

### **Panel of experts of the 1<sup>st</sup> Delphi round**

The panel of experts of the 1<sup>st</sup> Delphi round was recruited within the STELLAR network by sending out an invitation email to the network's mailing list in summer

2009. The list included 77 researchers from the 16 STELLAR partners. We aimed for the participation of the core group within the STELLAR network, that is 30-40.

The final sample consisted of 41 STELLAR members. The sample included a diverse mix of gender, academic status, work location and professional background of the researchers. 20 participants were senior researchers in executive positions, such as full professors or directors of research institutions. The sample consisted of 21 participants with a social sciences background and 20 participants from disciplines that focus mostly on technological aspects.

### **Panel of experts of the 2<sup>nd</sup> Delphi round**

In February 2010, we invited 511 TEL experts to participate in the online survey of the 2<sup>nd</sup> STELLAR Delphi round. Their expert status was based either on nomination by one of the STELLAR partners or on membership in the program committee of TEL-related conferences. In total, 230 experts followed our invitation to participate in the survey. Most of the European countries, America, Asia, and Australia were represented.

### **Panel of experts of the 3<sup>rd</sup> Delphi round**

In the 3<sup>rd</sup> Delphi round, we invited STELLAR members to participate in two face-to-face workshops in Freiburg, Germany in summer 2010. We prepared material based on the results of the 1<sup>st</sup> and 2<sup>nd</sup> Delphi round for the STELLAR-experts to work on collaboratively. 12 experts representing all eight work packages of the STELLAR network participated in the workshops and contributed to the elaborations of the Delphi results.

### **Panel of experts of the 4<sup>th</sup> Delphi round**

In January 2011, we invited 1500 experts to participate in the online survey and 569 (38%) participants responded to the multiple reminders. The majority of participants identified themselves as researchers, followed by educators, business people, and policy makers (see Figure 1).

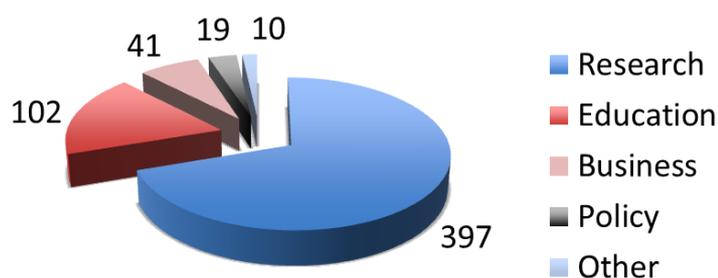


Figure 1. 4<sup>th</sup> Delphi round – Panel of experts.

The majority of researchers came from the disciplines of educational technology and computer sciences ( $n = 274$ ), whereas the educational sciences and psychology

were represented by 100 experts (see Figure 2). Finally, the remaining 23 researcher belonged to miscellaneous disciplines. The group of educators were mainly working in formal education settings ( $n = 81$ ). The strong emphasis of the Delphi study on Europe was reflected in the experts' country distribution ( $n_{\text{Europe}} = 359$ ,  $n_{\text{non-Europe}} = 209$ ). In Appendix B, the names of the participating experts in the 4<sup>th</sup> Delphi round are listed.

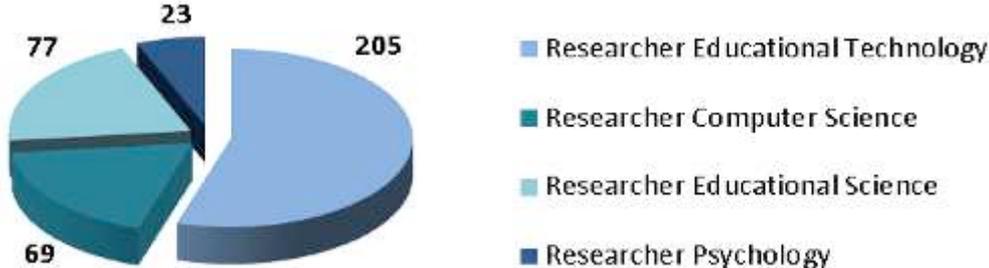


Figure 2. 4<sup>th</sup> Delphi round – Researchers in the panel of experts.

Previous deliverables have described in detail the 1<sup>st</sup> Delphi round and the planning of the 2<sup>nd</sup> Delphi round (D1.3, Spada et al., 2010), as well as the results of the 2<sup>nd</sup> and 3<sup>rd</sup> Delphi round (D1.3A, Spada et al., 2011). This report consequently provides a brief summary of the first three rounds and then focuses on the results of the 4<sup>th</sup> and 5<sup>th</sup> round. The latter will be presented first for the AoTs and then for the CRAs that have been identified and evaluated in the STELLAR Delphi study.



Figure 3. Experts of the 4<sup>th</sup> Delphi round – Country distribution.

## 2 Areas of Tension in TEL – Identification and Evaluation

The Areas of Tension (AoTs) were identified in the 3<sup>rd</sup> Delphi round on the base of the visionary statements that had been generated in the previous rounds. Since this process has already been described in great detail in D1.3A (Spada et al., 2011), below we will only briefly summarize the method and results for the 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> Delphi round before elaborating on the results of the final Delphi rounds.

### 2.1 Visionary Statements – 1<sup>st</sup> and 2<sup>nd</sup> Delphi Round

The 1<sup>st</sup> and 2<sup>nd</sup> Delphi rounds served to generate and evaluate visionary statements by researchers and stakeholders within the STELLAR network and beyond. A visionary statement portrays a fraction of a future scenario within the time frame of 15 years.

In the 1<sup>st</sup> Delphi round, an open answer format approach was used to generate visionary statements that were subsequently evaluated in the 2<sup>nd</sup> Delphi round. A sample of 41 researchers from the STELLAR network produced 134 statements in the 1<sup>st</sup> Delphi round, that were then reduced to 16 statements of particular significance by the Delphi research team (Kaendler et al., 2011; see Table 1) in a combination of individual and collaborative work phases. This set of statements was then presented to the global panel of experts in the 2<sup>nd</sup> Delphi round. In the online questionnaire, experts rated the *desirability* of each visionary statement and its likeliness to become reality within the next 15 years (*realism*; see Figure 4). After the experts had rated the set of 16 visionary statements, they were asked to suggest up to three additional visionary statements of their own. We analyzed these additionally generated visionary statements in the 3<sup>rd</sup> Delphi round.

By 2025, our learning history will be recorded resulting in a track record (including video) for example for evaluation purposes.

|             |                       |                       |                       |                       |                       |           |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------|
| unrealistic | <input type="radio"/> | realistic |
| undesirable | <input type="radio"/> | desirable |

Figure 4. Questionnaire of the 2<sup>nd</sup> Delphi round – Format of the visionary statements.

Table 1. 2<sup>nd</sup> STELLAR Delphi round – 16 visionary statements (MD denotes median, M mean, SD standard deviation), 5-point Likert scale with unrealistic (1), realistic (5), undesirable (1), and desirable (5)

| Item | Visionary statements evaluated in the 2 <sup>nd</sup> Delphi round   | Type | Scale     | MD | M (SD)      |
|------|--|------|-----------|----|-------------|
| 1    | By 2025, virtual experiences will dominate education.  | D    | realistic | 3  | 2.87 (1.17) |
|      |  |      | desirable | 2  | 2.49 (1.12) |
| 2    | By 2025, formal education of long running mass programs will become irrelevant in favor of networked and digitally supported personal learning trajectories.   | C    | realistic | 3  | 2.87 (1.16) |
|      |  |      | desirable | 3  | 3.16 (1.25) |
| 3    | By 2025, learning to type-write will replace learning to hand-write in early education.  | D    | realistic | 3  | 3.10 (1.32) |
|      |  |      | desirable | 2  | 2.30 (1.17) |
| 4    | By 2025, recognizing prior learning will be standard and technology plays a vital role in supporting both learners and assessors in accrediting what has been informally learnt.   | A    | realistic | 4  | 3.59 (1.03) |
|      |  |      | desirable | 4  | 3.96 (0.94) |
| 5    | By 2025, no content needs to be memorized because wearable content-aware devices will provide the relevant information.  | D    | realistic | 3  | 2.70 (1.32) |
|      |  |      | desirable | 2  | 2.06 (1.13) |
| 6    | By 2025, our learning history will be recorded resulting in a track record (including video) for example for evaluation purposes.  | B    | realistic | 4  | 3.44 (1.22) |
|      |  |      | desirable | 3  | 3.01 (1.21) |
| 7    | By 2025, key developments in TEL will mainly come from the gaming and entertainment industry.  | D    | realistic | 3  | 3.23 (1.12) |
|      |  |      | desirable | 2  | 2.30 (0.96) |
| 8    | By 2025, learners will no longer use a mouse or keyboard, but will interact with their computer only using eyes, hands and their brain.  | A    | realistic | 4  | 3.34 (1.23) |
|      |  |      | desirable | 4  | 3.52 (1.08) |
| 9    | By 2025, learners will be empowered to design their own think tools.   | A    | realistic | 4  | 3.33 (1.17) |
|      |  |      | desirable | 4  | 4.02 (1.01) |
| 10   | By 2025, intelligent software will support learners to filter information for quality and importance.  | A    | realistic | 4  | 4.04 (1.09) |
|      |  |      | desirable | 4  | 4.10 (1.10) |
| 11   | By 2025, inexpensiveness and ease of use of technology will enable diverse groups of people to access educational resources.   | A    | realistic | 4  | 4.05 (1.02) |
|      |  |      | desirable | 5  | 4.77 (0.50) |
| 12   | By 2025, students will start their school day by switching on their computer and logging in to "school" (from wherever they are at that time).   | C    | realistic | 3  | 3.39 (1.31) |
|      |  |      | desirable | 3  | 2.82 (1.28) |
| 13   | By 2025, microchips in our brain and drugs will allow us to control our mood, our motivation for learning and many other emotional aspects.  | E    | realistic | 2  | 2.27 (1.21) |
|      |  |      | desirable | 1  | 1.38 (0.75) |
| 14   | By 2025, students' report cards will include assessment of domain-general skills, such as computer-literacy, collaboration skills, mastery of reading and learning strategies.   | A    | realistic | 4  | 3.95 (1.05) |
|      |  |      | desirable | 4  | 3.77 (1.15) |
| 15   | By 2025, the boundary between formal and informal learning will have been blurred.   | A    | realistic | 4  | 3.75 (1.11) |
|      |  |      | desirable | 4  | 3.92 (1.08) |
| 16   | By 2025, students will be allowed to use technological devices in exams that are designed to assess students' abilities and knowledge while taking into account what the technological devices can do (e.g. draw graphs...). | A    | realistic | 4  | 4.27 (0.90) |
|      |  |      | desirable | 4  | 4.22 (0.87) |

The results of the 2<sup>nd</sup> Delphi round (see Table 1) were analyzed for patterns of heterogeneity versus homogeneity in the desirability and realism ratings. Dispersed patterns were expected to reveal possible tensions within TEL; for example, future trends that experts did not agree on whether they were desirable or not and that at least some experts believed to be realistic future developments. We found five patterns of frequency distributions (see Figure 5), two types of more homogeneous trends (Types A and E) and three heterogeneous trend types (Types B, C and D).

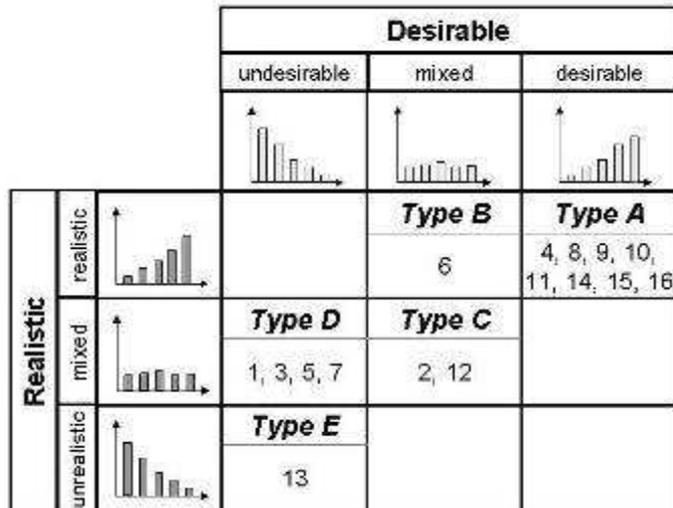


Figure 5. Visionary statements – Types of frequency distributions (item numbers are given for visionary statements shown in Table 1).

Visionary statements of the latter types discussed the introduction of technology in classrooms, the function and role of ubiquitous technology in learning, the personalization of learning trajectories and the role of data tracking for personalized learning. Because experts did not agree on the desirability (and/or realism) of these trends, they were seen as good indicators of possible future Areas of Tension.

## 2.2 Identifying Areas of Tension in TEL – 3<sup>rd</sup> Delphi Round

The 3<sup>rd</sup> Delphi round – a STELLAR-internal round – used a mixed methods approach to identify opposing and conflicting views on future developments in TEL by experts, the so called *Areas of Tension* (AoTs). Two Delphi workshops were conducted in Freiburg in summer 2010 with different STELLAR experts and the Delphi research team. Visionary statements were chosen as potential indicators of AoTs when the results of the previous, 2<sup>nd</sup> Delphi round showed them to possess high variability on the desirability dimension (see Figure 4, Type B and C). In addition to these quantitative results, the additionally proposed visionary statements of the 2<sup>nd</sup> Delphi round were used in the workshops in the following way: The workshop participants grouped together visionary statements that formed two opposing positions on a specific future development within TEL, and provided additional input from their multifaceted perspectives on this AoT. The Delphi team then refined the descriptions, resulting in the final set of five AoTs.

For the purpose of this report, we are presenting a shortened version of the Areas of Tension. The complete texts presented in the survey of the 4<sup>th</sup> Delphi round can be found at the end of this document in Appendix A, on the [STELLAR homepage at University of Freiburg](#) and in the previous deliverable D1.3A (Spada et al., 2011).

### ***Area of Tension 1: Data privacy vs. data tracking for personalized learning***

*Position A:* Data privacy will be a major concern in the future of TEL when data will be stored for personalized learning environments. The learners' data privacy, that is, the learner's control over the storage, use, and dissemination of his or her personal data can be endangered. Data privacy is an important goal because it prevents misuse of personal data, such as a person's learning history. The development of data security concepts as well as the teaching of data literacy skills that ensure maximal control over one's personal data will therefore be key focus of the future of TEL.

*Position B:* Keeping track of a learner's data for enabling personalization of learning is a key issue in TEL. With the help of detailed and accurate records, personalized instruction can facilitate learning by adapting to the learner's individual learning history, affective characteristics, learning styles, or interests. Future TEL environments will therefore collect and store large amounts of user data, and will communicate these data with other tools in order to provide the best possible support across learning contexts.

### ***Area of Tension 2: Digital divide despite technology spread***

*Position A:* Technological developments often sustain existing social inequities. For instance, developing countries have low levels of technological infrastructure and (computer) literacy as compared to industrial countries. Consequently, research has provided evidence that people who are already privileged in the usage of technology often benefit the most from new ICT developments. Hence, there is a real danger that future TEL-solutions, too, will sustain or even enlarge the already existing "digital divide" between people with and without access to educational and informational resources.

*Position B:* There are many promising initiatives and projects aiming at improving the technical infrastructure (e.g. one laptop per child) and creating the social preconditions (e.g. through teacher training) for offering access to educational and informational resources to the poor and disadvantaged. TEL-solutions that capitalize on the development and increasing spread of smaller, cheaper, and easier to use technological tools will empower disadvantaged people and thus help to reduce the digital divide. Thus, due to technological advances and the initiatives already taken by researchers, politicians, and other stakeholders, there is a realistic chance that we will be able to overcome the digital divide in the future.

### ***Area of Tension 3: Focused and critical processing of information vs. ubiquitous learning opportunities***

*Position A:* Ubiquitous access to information and communication resources can lead to distractions from the learning process. The resulting multitasking distracts students from the focused and elaborated processing of information. Further, the

vast amount of information easily leads to a fast and superficial processing of the learning content; therefore, TEL should concentrate on training essential skills for identifying and focusing on relevant aspects and elaborating on learning content. Learning activities and settings should aim for an attentive, conscious, and holistic learning experience, and for ensuring the acquisition of both factual and metacognitive knowledge.

*Position B:* TEL capitalizes on the possibilities offered by modern mobile and portable devices, which enable ubiquitous information access and thus ubiquitous learning opportunities. Today's students are "digital natives" who grew up with technology and use it naturally. They already have developed useful strategies and skills to find and handle the information they need. In addition, search engines and context-aware devices enable contextualized learning experiences by adapting the information they provide to the situation or context of the person. TEL should build on these societal and technological advances by making the world's information available and accessible to each learner at any time and any place.

#### ***Area of Tension 4: Approved practices vs. continuous innovation in the classroom***

*Position A:* Research on TEL should, whenever possible, be grounded in well-established educational theories, and in practices that have been proven beneficial for learning. The ultimate goal of TEL in the classroom should be to create and support reliable, well established and highly successful school practices. New technologies should only be adopted into real-world classrooms when their usefulness for learning has been proven. Usage of technology as an end in itself should be prevented. Thus, TEL-research should aim to clarify in which ways a new technology can enhance pedagogical concepts, and assure that only those TEL-solutions that have been proven to be effective for learning are applied in the classroom.

*Position B:* The adoption of new technological tools in the classroom often sparks the employment of new and innovative educational methods and concepts. Therefore, new technological tools and TEL-solutions should be employed in real-world classrooms as early as possible, enabling a constant evolution and shaping of learning settings and educational practices. It is therefore important that teachers are familiar with new technological developments and quickly integrate them into their classrooms. In doing so, they will continuously take their educational practices to the next level.

#### ***Area of Tension 5: Standardized vs. individual learning paths***

*Position A:* By introducing individual learning paths, we run the risk of losing common standards and educational norms. Standardization is essential for proper assessment, accreditation, and comparison of degrees. Even more important, learners will often lack the skills and competencies to create a coherent sequence

of learning events in their area of interest. As novices in that field they will have difficulties to identify meaningful learning objectives. Standardized learning paths can provide academic guidance and faster access to the essential contents of a domain. Therefore, TEL should focus on offering learners standardized learning trajectories that have been professionally created and evaluated.

*Position B:* The development of new technological tools and changes of the educational landscape enable people to create their own learning paths regarding content, interests, needs, and skills. Individual learning profiles guarantee a more comprehensive and transdisciplinary evolution of knowledge. Furthermore, individualized learning paths can lead to increased motivation because learners deal with subjects they are interested in and feel responsible for. Consequently, we should support learners in their individual ideas about what and how to learn and provide them with technological tools that make this process possible.

## **2.3 Evaluation of Areas of Tension in TEL – 4<sup>th</sup> Delphi Round**

The Areas of Tension that had been generated in the 3<sup>rd</sup> Delphi round were evaluated by the global panel of experts (see section 1 for details) of the 4<sup>th</sup> Delphi round on several dimensions. We will describe the design of the questionnaire below before presenting the results of this evaluation.

### **2.3.1 Questionnaire of the 4<sup>th</sup> Delphi round**

The questionnaire of the 4<sup>th</sup> Delphi round consisted of two parts. The first part addressed the Areas of Tension and will be described below (see Figure 6). The second part on the Core Research Areas will be presented later in chapter 3 of this report.

Experts were presented with descriptions of each of the five AoTs (see chapter 2.2). For each AoT, they were asked to estimate the *strength of each tension today* (item 1) and *in the future* (item 4). Nested between these items, the experts had to indicate how strongly they identified with the two positions of the AoT, forming the dependent variables *identification with position A* (item 2) and *identification with position B* (item 3). Finally, experts gave their opinion on how much the AoT will impact on certain sectors (*impact of tension*, item 5) and how influential certain actors will be concerning the future development of the tensions (*influence of actors on the tension*, item 7).

We were primarily interested in whether the experts would expect the tensions' strength to change in the future and which actors or sectors of society and life would play a role in this process. Even further, we analyzed whether experts with different professional backgrounds would show differing perspectives on the several dimensions for the five AoTs. Therefore, we computed a series of repeated-measure analyses of variance (ANOVA) for each variable that we will demonstrate

below for *strength of tensions* as an example of the analyses performed for all dependent variables. The first repeated-measures factor of the ANOVA for *strength of tensions* contained the levels *today* and *in the future*. A second repeated-measures factor contained five levels for the different AoTs (AoT 1 to 5), so we could detect differences in development between the various AoTs. The third and last, between-subjects factor had three levels for the *groups of experts* (researchers, educators, policy makers/business people/other). For some analyses, we only focused on one of these groups, the *subgroups of researchers*. It then contained the levels *educational sciences/psychology*, *educational technology*, and *computer sciences*, allowing us to further analyze this sub-sample of experts. We are presenting below only the most relevant results of these analyses and their critical reflection.

1. **How strong do you think the tension between Position A and Position B is today?**  
Not strong □□□□ Very strong
2. **How strongly do you identify with Position A?**  
Not at all □□□□ Very much
3. **How strongly do you identify with Position B?**  
Not at all □□□□ Very much
4. **How strong do you think the tension between Position A and Position B will be in 10 years?**  
Not strong □□□□ Very strong
5. **In the next 10 years: How much impact will this Area of Tension have on**  

|                    |           |              |
|--------------------|-----------|--------------|
|                    | no impact | large impact |
| society in general | □□□□      |              |
| educational sector | □□□□      |              |
| TEL research       | □□□□      |              |
| your field of work | □□□□      |              |
6. **Any comments, questions, remarks, or ideas concerning this Area of Tension in relation to your field of work:**
7. **In the next 10 years: How much influence will the following actors have on the developments within this Area of Tension?**  

|                            |              |                 |
|----------------------------|--------------|-----------------|
|                            | no influence | large influence |
| researchers                | □□□□         |                 |
| policy makers/politicians  | □□□□         |                 |
| practitioners in education | □□□□         |                 |
| society                    | □□□□         |                 |
| learners/teach-users       | □□□□         |                 |

Figure 6. Questionnaire items of the 4<sup>th</sup> Delphi round – Areas of Tension.

### 2.3.2 Results of the 4<sup>th</sup> Delphi round and discussion

Regarding the future development of the AoTs, we found an interaction effect,  $F(9.11, 1878.55) = 15.75, p < .001, \eta_p^2 = .03$ , of the factors *strength of tensions* and AoTs: the experts predicted opposing developments in strength for the different AoTs. While the tensions described by AoT 2, 3 and 4 (*digital divide despite technology spread, focused and critical processing of information vs. ubiquitous learning opportunities, approved practices vs. continuous innovation in the classroom*) were hoped to slightly decrease over time, AoT 5 (*standardized vs.*

*individualized learning paths*) was seen to stay problematic and issues of *data privacy vs. personalized learning (AoT1)* were even expected to increase over the next ten years (see Table 2).

Table 2. 4<sup>th</sup> STELLAR Delphi round – Results of the Areas of Tension (identification with positions, strength of tension)

| AoT            | Strength of the tension (n = 504) |                         | Identification with positions (n = 517) |             |
|----------------|-----------------------------------|-------------------------|---|-------------|
|                | today<br>M (SE)                   | in the future<br>M (SE) | A<br>M (SE)                             | B<br>M (SE) |
| 1              | 3.32 (0.05)                       | 3.55 (0.05)             | 3.27 (0.05)                             | 3.64 (0.05) |
| 2              | 3.43 (0.05)                       | 3.24 (0.05)             | 3.17 (0.05)                             | 3.56 (0.05) |
| 3              | 3.41 (0.05)                       | 3.23 (0.06)             | 3.45 (0.05)                             | 3.71 (0.05) |
| 4              | 3.35 (0.05)                       | 3.22 (0.05)             | 3.12 (0.05)                             | 3.68 (0.05) |
| 5              | 3.49 (0.05)                       | 3.55 (0.05)             | 3.01 (0.05)                             | 3.83 (0.05) |
| Marginal means | 3.40 (0.05)                       | 3.36 (0.05)             | 3.20 (0.05)                             | 3.68 (0.05) |

Note. Answers were given on a five-point Likert-scale ranging from 1 (not strong) to 5 (very strong) for *Strength of the tension* and 1 (not at all) to 5 (very much) for *Identification of positions*. Sample sizes vary because not all experts completed all items.

The two positions on the AoTs were formulated so that *position A* adopted an education-oriented perspective on the use of technology in educational settings while *position B* focused on the benefits of technology for education. Interestingly, across all AoTs experts identified more strongly with the latter position (B),  $F(1, 516) = 102.88, p < .001, \eta_p^2 = .17$ . However, when we looked more closely at results for different groups of researchers, we found that those from the educational sciences/psychology disciplines identified themselves less with *position B* than researchers coming from educational technology or computer sciences (see Figure 7 and Table 3), an interaction effect,  $F(2, 338) = 5.494, p = .004, \eta_p^2 = .03$ . It thus seems that the TEL community overall saw benefits of using technology in an education setting with educational scientists and psychologists being more critical. Given the gap in implementing ICTs in real-life classrooms, the latter perspective seems to capture issues that are important and relevant for practitioners in education and could explain why close to all schools are equipped with ICTs and have Internet access, but not even 60% of teachers integrate ICTs in their instructional practices according (Law, Pelgrum, & Plomb, 2008). These findings for formal education demonstrate that despite the progress in the research field of TEL, the translation of research findings into educational practices falls short of expectations.

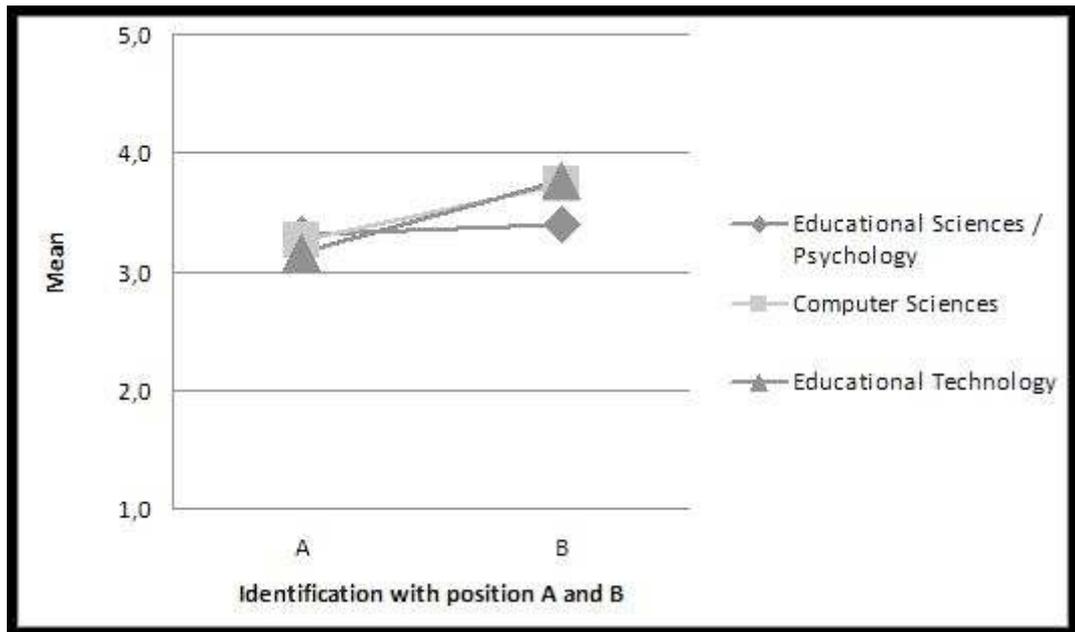


Figure 7. Identification with Positions A (education-oriented perspective) and B (focus on the benefits of technology) by Group of Researcher.

Table 3. Results of the 4<sup>th</sup> STELLAR Delphi round – Identification with positions for subgroups of Researcher (n = 341)

| Group Researcher                         | Identification with positions (n = 341) |             |
|--|---|-------------|
|  | A<br>M (SE)                             | B<br>M (SE) |
| <i>Educational Sciences / Psychology</i> | 3.32 (0.07)                             | 3.40 (0.07) |
| <i>Computer Sciences</i>                 | 3.26 (0.08)                             | 3.74 (0.08) |
| <i>Educational Technology</i>            | 3.16 (0.05)                             | 3.77 (0.05) |
| <b>Marginal means</b>                    | 3.21 (0.04)                             | 3.64 (0.04) |

When we designed the questionnaire, we anticipated that certain sectors may be impacted differently by the AoTs. Indeed, experts estimated that the *educational sector* will be impacted the most by the tensions, followed by *TEL research* and the *society in general/the experts' own field of work* across all AoTs,  $F(2.60, 1285.07) = 104.55, p < .001, \eta_p^2 = .18$ . This finding shows that the AoTs are not a purely academic problem that has to be addressed within the research community, but that these tensions are seen to impact educational practice above all else and are relevant to society in general.

In addition, different AoTs were thought to impact certain sectors differently, an interaction effect,  $F(9.54, 4713.57) = 59.70, p < .001, \eta_p^2 = .11$ . While the educational sector seemed to be impacted most by *AoT 3 critical and focused learning vs. ubiquitous learning opportunities*, *AoT 4 approved practices vs. innovation in the classroom*, and *AoT 5 standardized vs. individualized learning paths*, the impact on the society in general appeared to be strongest by *AoT 1 data privacy vs. data tracking for personalized learning* and *AoT 2 digital divide despite*

*technology spread* and vice versa (see Table 4). This distribution of the impact of the tensions on the two largest sectors, society in general and the educational sector underlines the significance of acting to resolve these tensions.

Table 4. Results of the 4<sup>th</sup> STELLAR Delphi round – Impact of Areas of Tension on certain sectors (n = 495)

| AoT                   | Society in general<br><i>M (SE)</i> | Educational sector<br><i>M (SE)</i> | TEL research<br><i>M (SE)</i> | Your field of work<br><i>M (SE)</i> | Marginal means |
|-----------------------|-------------------------------------|-------------------------------------|-------------------------------|-------------------------------------|----------------|
| 1                     | 3.69 (0.05)                         | 3.70 (0.04)                         | 3.65 (0.05)                   | 3.45 (0.05)                         | 3.62 (0.05)    |
| 2                     | 3.74 (0.05)                         | 3.69 (0.04)                         | 3.36 (0.05)                   | 3.15 (0.05)                         | 3.49 (0.05)    |
| 3                     | 3.51 (0.05)                         | 3.90 (0.05)                         | 3.67 (0.04)                   | 3.55 (0.05)                         | 3.66 (0.05)    |
| 4                     | 3.02 (0.05)                         | 3.92 (0.04)                         | 3.84 (0.04)                   | 3.60 (0.05)                         | 3.60 (0.05)    |
| 5                     | 3.28 (0.05)                         | 4.03 (0.04)                         | 3.85 (0.04)                   | 3.55 (0.05)                         | 3.68 (0.05)    |
| <b>Marginal means</b> | 3.45 (0.05)                         | 3.85 (0.04)                         | 3.67 (0.05)                   | 3.46 (0.05)                         |                |

Given these findings of the impact of the AoTs on the various sectors, it is desirable to investigate by whom the tensions can be acted upon. We had hypothesized that the development of tensions' strengths could be influenced differently by several actors within society. The experts' answers confirmed this assumption,  $F(3.40, 1649.85) = 41.32, p < .001, \eta_p^2 = .08$ , and comparisons between pairs of actors revealed that experts expected *practitioners in education* and *policy makers* to have the largest influence on the tensions, followed by *researchers* and *learners/end-users* and lastly *society*. This result corresponds well to the finding presented above that the educational sector will be impacted the most by the AoTs overall, followed by TEL research. The experts thus expect a symmetrical relationship between tensions and actors: those who are impacted by tensions also are thought to be able to (positively) influence them.

A closer look on AoTs separately again revealed differential influences of actors, (see Table 5), an interaction effect,  $F(12.81, 6224.16) = 86.25, p < .001, \eta_p^2 = .15$ . Policy-makers were thought to be the most influential actors on AoT 1 *data privacy vs. data tracking for personalized learning* and AoT 2 *digital divide despite technology spread*. Regarding the development of AoT 3 *focused and critical processing of information vs. ubiquitous learning opportunities* however, experts anticipated policy makers to make the smallest contribution and researchers in turn to have a large influence. This importance of researchers was similarly seen for the integration of ICTs in the classroom (AoT 4), and the balance between standardized and individualized learning paths (AoT 5). Taken together, these results on the impact of the AoTs on different sectors and the influence of several actors on the development of the tensions reveal that the experts, while acknowledging the future impact of the tensions, have an optimistic view on our means of addressing these challenges. Actors from the sectors who will be impacted the most by a specific AoT also have the largest influence on the development of the strength of the tensions. These results may also inform a potential strategy of allocating

resources to resolving the tensions. Broader policy issues such as *AoT 1 data privacy vs. data tracking for personalized learning* and *AoT 2 digital divide despite technology spread* both need to and can be addressed effectively on a societal level. *AoT 3 critical and focused learning vs. ubiquitous learning opportunities*, *AoT 4 approved practices vs. innovation in the classroom*, and *AoT 5 standardized vs. individualized learning paths* are more focused on the educational sector and will require the funding of a joint effort of researchers and educators.

Table 5. Results of the 4<sup>th</sup> STELLAR Delphi round – Influence of actors on the tension (n = 487)

| AoT            | Researchers   | Policy maker s/ politician | Practitioners in education | Society       | Learners/end-users | Marginal means |
|----------------|---------------|----------------------------|----------------------------|---------------|--------------------|----------------|
|                | <i>M (SE)</i> | <i>M (SE)</i>              | <i>M (SE)</i>              | <i>M (SE)</i> | <i>M (SE)</i>      |                |
| 1              | 3.35 (0.05)   | 4.10 (0.04)                | 3.39 (0.04)                | 3.46 (0.05)   | 3.43 (0.05)        | 3.55 (0.05)    |
| 2              | 3.30 (0.05)   | 3.97 (0.04)                | 3.34 (0.05)                | 3.51 (0.05)   | 3.04 (0.05)        | 3.43 (0.05)    |
| 3              | 3.72 (0.05)   | 3.08 (0.05)                | 3.81 (0.04)                | 3.38 (0.05)   | 3.78 (0.05)        | 3.55 (0.05)    |
| 4              | 3.76 (0.05)   | 3.41 (0.05)                | 4.04 (0.04)                | 3.01 (0.05)   | 3.40 (0.05)        | 3.52 (0.05)    |
| 5              | 3.73 (0.05)   | 3.67 (0.05)                | 3.87 (0.04)                | 3.14 (0.05)   | 3.43 (0.05)        | 3.57 (0.05)    |
| Marginal means | 3.57 (0.05)   | 3.65 (0.05)                | 3.69 (0.04)                | 3.30 (0.05)   | 3.42 (0.05)        |                |

Lastly, as mentioned above, we also investigated whether experts with varying professional backgrounds would evaluate first, the impact of AoTs and second, the influence of actors differently in two separate analyses. We compared the following groups with each other: *researcher*, *educator*, and *policy-maker/business people/other*. We found differences for the groups of experts concerning the *influences of actors on the tension*,  $F(2, 484) = 5.03$ ,  $p = .007$ ,  $\eta_p^2 = .02$ , and then also for the *impact of AoT on certain sectors*,  $F(2, 492) = 4.05$ ,  $p = .018$ ,  $\eta_p^2 = .02$  (see Table 6). Further tests revealed that across all five AoTs, educators compared to researchers considered actors to be more influential on the tensions and impacts of AoTs on certain sectors to be bigger (for both post-hoc tests,  $p < .02$ ). Since educators experience the reality of TEL daily in their work, it is particularly interesting that this group seemed to both see the potential of influencing AoTs in the future while they were aware of the AoTs impact on their field of work.

Table 6. Results of the 4<sup>th</sup> STELLAR Delphi round – Impact of tension and influence of actors for the Group of Experts

| Group of Experts                         | Impact of tension (n = 495) | Influence of actors (n = 487) |
|--|-----------------------------|-------------------------------|
|  | <i>M (SE)</i>               | <i>M (SE)</i>                 |
| Researcher                               | 3.57 (0.03)                 | 3.48 (0.03)                   |
| Educators                                | 3.77 (0.06)                 | 3.67 (0.06)                   |
| Business people / policy-makers / others | 3.61 (0.08)                 | 3.59 (0.07)                   |

Overall, we were able to confirm the Areas of Tension strengths through the experts' evaluations. Most experts highlighted the benefits of implementing

technology in education, sometimes unaware of the problems educators have integrating ICTs in their classrooms. While the tension of opposing the loss of data privacy to tracking of data for personalized learning was seen to increase in the future, most tensions were expected to weaken over time. This optimism of experts about the future trend of the strength of the tension could also be seen in their predictions whether these tensions could be positively influenced in the future. Still, experts were very much aware of the potential impact of tensions on both the educational sector and on TEL research.

### 3 Core Research Areas in TEL – Development and Prioritization

The Core Research Areas (CRAs) were developed on the basis of the results of the previous rounds in the 3<sup>rd</sup> Delphi round together with STELLAR members. The development process of the CRAs from the 1<sup>st</sup> to the 3<sup>rd</sup> Delphi round was presented in detail in D1.3A (Spada et al., 2011); therefore, we restrain the presentation of the 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> Delphi round to a short summary in the following sections.

#### 3.1 Future Trends in TEL – 1<sup>st</sup> and 2<sup>nd</sup> Delphi Round

In the 1<sup>st</sup> Delphi round, we used a survey employing open-ended questions on the following questions to STELLAR members: *important research themes for a future TEL research program, future technological, and societal developments that might have an impact on TEL*. The expert answers to the open-ended survey items were grouped into topics and subtopics, using a semi-qualitative approach. The subtopics of the 1<sup>st</sup> Delphi round were used in the questionnaire design process of the 2<sup>nd</sup> Delphi round. Figure 8 shows an example of the resulting items in the online questionnaire for the Future Trends (future research themes, future technological developments, and future societal challenges). Experts rated each item for its importance for/impact on TEL in the future.

**PART 1: Future Societal Demands & Challenges Influencing TEL**

What key societal demands and challenges will Technology-Enhanced Learning have to respond to in the future? (presented in random order)

|  | not<br>important         |                          |                          | very<br>important        |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| Adapt education to new generations of students (e.g. "digital natives" that grew up with technology) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Provide teacher training in order to improve formal education  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Lifelong learning  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Political usage of new media   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**PART 2: Future Technological Developments Affecting TEL**

What key technological developments will have an impact on Technology-Enhanced Learning in the future? (presented in random order)

|  | no<br>impact             |                          |                          | high<br>impact           |
|--|--------------------------|--------------------------|--------------------------|--------------------------|
| Technology spread (smaller, cheaper, easier technological tools) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Augmented & virtual reality                                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Mobile (portable) computing technologies                         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Figure 8. Questionnaire of the 2<sup>nd</sup> Delphi round – Format of the future research themes.

The results of the 2<sup>nd</sup> Delphi round on Future Trends in TEL showed that in general, there were some variations within the experts' evaluations for the different items of the Future Trends; however, the overall ratings of the Future Trends were fairly high for all three dimensions. This finding revealed that the experts did not only evaluate research themes to play an important role for the future of TEL and TEL research but also estimated technological developments and societal challenges to be driving factors for the future of TEL and TEL research. This led us to the promotion of specific Core Research Areas that can provide valuable guidelines for future work in these fields. A *Core Research Area* represents a comprehensive research theme in integration with societal challenges to be addressed and technological developments.

### **3.2 Development of Core Research Areas in TEL – 3<sup>rd</sup> Delphi Round**

As mentioned in chapter 2.2, the 3<sup>rd</sup> Delphi round was another STELLAR-internal round that was held in form of two Delphi workshops in summer 2011 in Freiburg. In the second Delphi workshop, we developed the Core Research Areas (CRAs) together with STELLAR experts. We used the results of the 2<sup>nd</sup> Delphi round on the three questions about Future Trends as a starting point. A Core Research Area integrates all three dimensions: societal challenges/demands for TEL, technological developments, and research themes. The STELLAR experts were asked to develop such Core Research Areas while focusing on the Future Trends that were rated to be most important/of high impact and supplementing these findings with their individual expertise in the field of TEL. The Freiburg Delphi team developed an exemplary Core Research Area including a title and a short description that served to illustrate the task. This exemplary Core Research Area included *lifelong learning* as societal challenge, *collaboration and communication tools* as technological development, and the research theme *collaborative learning*. We named this Core Research Area *Computer-Supported Collaborative Learning: Develop collaboration tools and promote collaboration skills to support lifelong learning* (see Figure 9).

### Example 1

#### **Integration of the three dimensions:**

**Societal challenge for TEL:** Lifelong learning

**Technological development:** Collaboration & communication tools

**Research theme:** Collaborative learning

**Title:** Computer-Supported Collaborative Learning: Develop collaboration tools and promote collaboration skills to support lifelong learning

**Description:** Today's information age requires employees to constantly update their knowledge and gain new skills. Computer-Supported Collaborative Learning (CSCL) can support these lifelong learning processes. CSCL aims to promote learning that takes place during collaborative activities such as problem-solving, decision-making, design, argumentation, etc., and is supported by technology. It integrates research on how collaboration tools and environments can be designed to foster learning, as well as research on how learners can be taught skills for effective collaboration.

Figure 9. Exemplary Core Research Area for the second Delphi workshop: CSCL.

The final set of 11 Core Research Areas was based on the outcome of the second Delphi workshop. The Freiburg-Delphi team refined the suggested Core Research Areas in close cooperation with STELLAR experts. The exact description of the 11 Core Research Areas can be found on the [STELLAR homepage at University of Freiburg](#) in the previous deliverable (D1.3A, Spada et al. 2011). For the purpose of this report, we present a short summary of the 11 Core Research in alphabetical order:

#### ***Computer-Supported Collaborative Learning***

As learners are increasingly connected through the use of computers, there is raised awareness of the potential of collaborative learning, supported by computers. What research is needed to supplement the body of knowledge already established in this area?

#### ***Connection between Formal and Informal Learning***

Both formal and informal learning experiences are essential in a modern knowledge society. However, transfer between formal learning environments, such as schools, and informal learning environments, such as online communities or museums, is still relatively rare. How can digital technologies be used to support the two-way knowledge exchange between out-of-school learning and in-school learning?

#### ***Contextualized Learning***

Learning is increasingly taking place in a wider range of contexts, particularly enabled by the use of mobile devices connected to the Internet. Research is needed, for instance, to explore how far interacting with a smart tool for contextualized learning influences interaction with the real world and with other students.

#### ***Emotional and Motivational Aspects of Technology-Enhanced Learning***

Research on emotional and motivational factors is now a growing research area. Learners' attitudes towards new technologies, together with their motivation for learning, influence the effectiveness of TEL. A question could be: What motivates people to participate in, and contribute to, collaborative learning processes?

### ***Improving Practices of Formal Education***

New technological developments offer the potential for innovative and progressive approaches to improving practices in formal education. How can future TEL research in this field support educators to make the best use of this potential?

### ***Informal learning***

Informal learning increasingly takes place in technology-enhanced settings, for example, when people communicate with others in an online forum, interact with artefacts in a museum, use their mobile phone to navigate a map, or search for information on the Internet. Research is needed to promote this type of learning without reducing motivational aspects of informal settings.

### ***Interoperability***

Efficient use of novel technological tools, for instance to create mashups, requires research and developments that improve the interoperability of tools and devices. Future research could explore how to define, enforce, and create application profiles that specify contextual requirements without the interoperability between different devices breaking down.

### ***Personalisation of Learning***

Technology-enhanced learning environments increasingly offer possibilities for adapting and personalising learning experiences. However, research is needed to understand better the requirements and constraints of personalisation.

### ***Reducing the Digital Divide***

There is growing concern about the gap between individuals with access to modern information technology and individuals without such access. How can research in TEL prevent the introduction of technology-enhanced learning exacerbating existing divides in society, whilst at the same time contribute to alleviating such divides?

### ***Ubiquitous and Mobile Technology and Learning***

With the ongoing spread and availability of mobile devices, such as mobile phones or Personal Digital Assistants (PDAs), learning opportunities are increasingly becoming ubiquitous. Research is needed to better understand the impact of mobile technologies, and the ubiquitous availability of information and learning resources, on students' learning practices.

### ***Workplace Learning***

Today's work practices require a constant update of work-related knowledge and the acquisition of new skills. Increasingly, the evidence about an individual's progress, captured by computers, will be used to identify the user's current knowledge and will inform and support their workplace learning.

### 3.3 Prioritization of the Core Research Areas – 4<sup>th</sup> Delphi Round

After the experts had evaluated the five Areas of Tension in the first part of the questionnaire (see chapter 2.3), they continued with the second part of the questionnaire on the 11 Core Research Areas. First, we presented descriptions of the 11 Core Research Areas (see D1.3A, Spada et al. 2011; or on the [STELLAR homepage at University of Freiburg](#)). Then, we asked the experts to rank the 11 Core Research Areas for their importance for TEL research in the next 10 years (see Figure 10 or Appendix A at the end of this document).

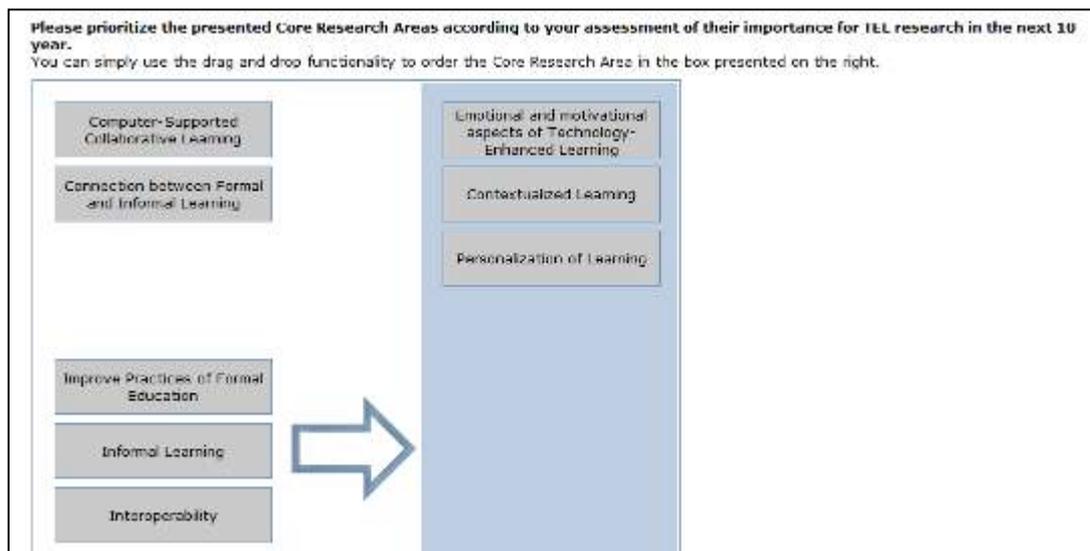


Figure 10. Questionnaire of the 4<sup>th</sup> STELLAR Delphi round – ranking the CRAs.

We analyzed the experts ranking data with the non-parametric equivalent of an analysis of variance for significant differences between the mean rank sums. Figure 10 presents the mean rank sums of the 11 Core Research Areas based on the data of 498 experts. Friedman's ANOVA revealed that overall the mean ranks of the Core Research Areas differ significantly from each other,  $\chi^2(10) = 552.32, p < .001$ . This result substantiates the relevance of the rank order of the CRAs presented in Figure 10.

We were especially interested in the rank orders of the various groups of experts who participated in the 4<sup>th</sup> Delphi round for gaining more information that could be relevant for funding agencies. In Figures 13 to 15, we point out changes in rank order with green and red arrows; these arrows indicate changes of at least two ranks in comparison to the compared rank order. First, we compared the researcher groups with each other; then, we compared educators, policy-makers and business people with both researcher groups.

### Experts of the 4<sup>th</sup> STELLAR Delphi round (n = 498):

1. (4.52) Connection between informal and formal learning
2. (4.99) Computer-supported collaborative learning
3. (5.13) Personalized learning
4. (5.14) Contextualized learning
5. (5.54) Ubiquitous and mobile technology and learning
6. (5.60) Improve practices in formal education
7. (6.26) Emotional and motivational aspects of TEL
8. (6.58) Informal learning
9. (7.03) Reducing the digital divide
10. (7.09) Workplace learning
11. (8.11) Interoperability

Figure 11. 4<sup>th</sup> Delphi round results – rank sums and order of the CRAs.

When analyzing the rank orders of the researcher groups *computer sciences/educational technology* (Figure 12) and *educational sciences/psychology* (Figure 13), only marginal differences can be identified. The CRA *Improve practices in formal education* is of higher importance for researchers with an educational sciences/psychology background and the CRA *Personalized learning* was estimated to be less important for future research in TEL compared to researchers with a background in computer sciences or educational technology. This finding is surprising in the way that we expected the groups of researchers to reveal differing rank orders. On the contrary, the rank orders demonstrate the shared vision for future TEL within the TEL research community.

**Researchers: *computer sciences/educational technology***  
**(n = 243)**

1. (4.50) Connection between informal and formal learning
2. (4.98) Personalized learning
3. (5.02) Computer-supported collaborative learning
4. (5.12) Contextualized learning
5. (5.49) Ubiquitous and mobile technology and learning
6. (5.85) Improve practices in formal education
7. (5.95) Emotional and motivational aspects of TEL
8. (6.76) Informal learning
9. (7.08) Workplace learning
10. (7.18) Reducing the digital divide
11. (8.07) Interoperability

Figure 12. 4<sup>th</sup> Delphi round results – rank sums of the CRAs for researchers from computer sciences/educational technology.

**Researchers: *educational sciences/psychology* (n = 85)**

1. (3.98) Connection between informal and formal learning
2. (4.33) Computer-supported collaborative learning
3. (4.54) ↑ Improve practices in formal education
4. (5.16) Contextualized learning
5. (5.74) ↓ Personalized learning
6. (6.00) Ubiquitous and mobile technology and learning
7. (6.26) Emotional and motivational aspects of TEL
8. (6.27) Informal learning
9. (7.25) Workplace learning
10. (7.35) Reducing the digital divide
11. (9.12) Interoperability

Figure 13. 4<sup>th</sup> Delphi round results – rank sums of the CRAs for researchers from educational sciences/psychology.

In contrast to the researchers from educational sciences/psychology (Figure 13), educators ranked *personalized learning* on top of their list (see Figure 14). The second CRA that was also ranked higher by educators compared to the researchers from educational sciences/psychology addresses the need for *reducing the digital divide*. These two CRAs incorporate the assumptions that all learners need to benefit from education that fits their specific needs and affordances. A third CRA was ranked higher by educators compared to educational researcher, that is, the use of *ubiquitous and mobile technology for learning*. Especially the relevance of research on personalized learning for practitioners in education should be

considered when suggesting future research programs in TEL. Surprisingly, educators estimated research on *improving practices in formal education* and to be less important in the future compare to researchers from educational sciences/psychology. In addition, the CRA *Emotional and motivation aspects of TEL* was ranked as less important by educators compared to both researcher groups.

### **Educators (n = 88)**

1. (4.92) ↑ Personalized learning
2. (4.94) Connection between informal and formal learning
3. (5.13) Computer-supported collaborative learning
4. (5.28) ↑ Ubiquitous and mobile technology and learning
5. (5.56) Contextualized learning
6. (5.62) ↓ Improve practices in formal education
7. (6.23) ↑ Reducing the digital divide
8. (6.76) Informal learning
9. (6.89) ↓ Emotional and motivational aspects of TEL
10. (7.32) Workplace learning
11. (7.84) Interoperability

Figure 14. 4<sup>th</sup> Delphi round results – rank sums of the CRAs for educators.

We compared the rank order of the participating business people and policy-makers to the rank order of both researchers groups. The arrows however illustrate changes of ranks compared to the larger researcher group – researcher from computer sciences/educational technology.

Similar to educators, business people who participated in the 4<sup>th</sup> Delphi round evaluated research on *emotional and motivational aspect of TEL* and on *improving practices in formal education* to be less important in the future compared to both researcher groups (see Figure 15). On the other hand, business people saw an increased relevance of *informal learning* and *workplace learning* in contrast to the researchers. The higher ranks of these two CRAs could reflect the relevance of informal learning for education in the working sector.

### Business people (n = 38)

1. (4.68) Connection between informal and formal learning
2. (4.79) Computer-supported collaborative learning
3. (4.92) Personalized learning
4. (5.00) Contextualized learning
5. (5.08) Ubiquitous and mobile technology and learning
6. (6.03) ↑ Informal learning
7. (6.47) ↑ Workplace learning
8. (6.71) ↓ Improve practices in formal education
9. (7.00) ↓ Emotional and motivational aspects of TEL
10. (7.13) Interoperability
11. (8.18) Reducing the digital divide

Figure 15. 4<sup>th</sup> Delphi round results – rank sums of the CRAs for business people.

Together with educators, policy-makers (see Figure 16) viewed the CRA *Reducing the digital divide* to be more important and the CRA *Emotional and motivational aspect of TEL* to be less important in the future compared to the researchers' rank order. However, policy makers were the only group of experts to prioritize the CRA *Improve practices in formal education* as the most important topic for future research programs.

### Policy makers (n = 15)

1. (4.27) ↑ Improve practices in formal education
2. (4.53) Personalized learning
3. (4.60) ↓ Connection between informal and formal learning
4. (5.33) Computer-supported collaborative learning
5. (5.87) Contextualized learning
6. (6.13) Ubiquitous and mobile technology and learning
7. (6.27) ↑ Reducing the digital divide
8. (6.40) Informal learning
9. (6.93) ↓ Emotional and motivational aspects of TEL
10. (7.60) Workplace learning
11. (8.07) Interoperability

Figure 16. 4<sup>th</sup> Delphi round results – rank sums of the CRAs for policy makers.

In conclusion, according to the experts of the 4<sup>th</sup> Delphi round future research programs in TEL should especially focus on the *connection between formal and informal learning*, *CSCL*, and *personalized learning*. The subtle deviations in the CRA rank orders between the subgroups reflect the various professional angles on important and relevant research issues in TEL but do not devalue the overall

Imagine that research funding is made available to carry out research projects in TEL. You can apply for a research project in one of the presented research areas.

Please select one of the presented Core Research Areas in which you would apply for a research project.

Please sketch out the project you would like to investigate until 2020, and describe how it addresses the Core Research Area selected above.

In contrary, the high agreement especially among the researchers on research themes for future TEL has to be highlighted and portrays a shared vision for future research questions.

Collaborating partners/institutions:

Justification (i.e. societal, technological, and scientific relevance):

### 3.4 Project Proposals by Experts of the 4<sup>th</sup> Delphi Round

We also asked the experts to sketch a research project proposal for one Core Research Area of their choice. The project proposal should include a title, research questions/short description, collaborating partners/institutions, and a justification (see Figure 17).

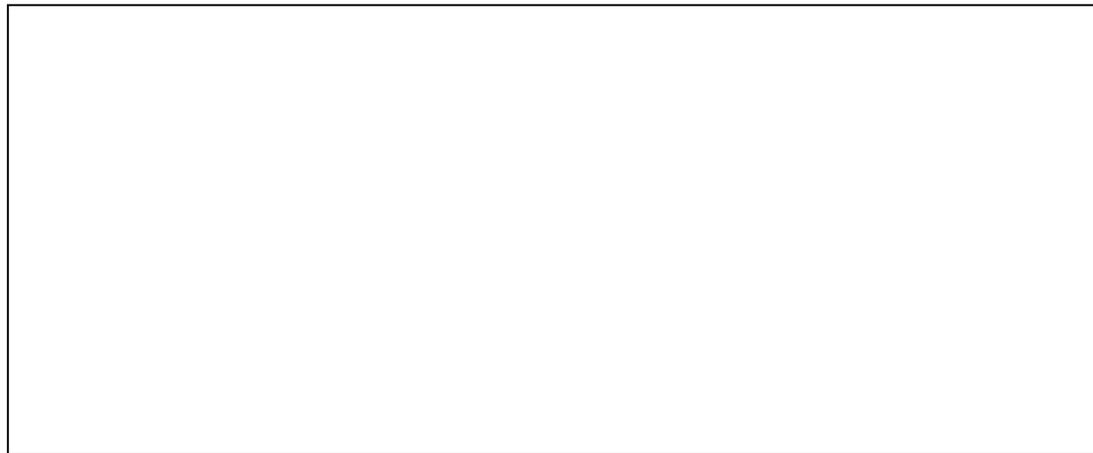


Figure 17. Questionnaire of the 4<sup>th</sup> Delphi round – research project proposals.

The panel of experts contributed 311 project proposals for the 11 Core Research Areas with a varying number of project proposals generated per Core Research Area. To give an example of the project proposals, a project proposal is presented below that was provided for the Core Research Area *Computer-supported collaborative learning*:

**Project title**

*Communities of practice in teaching/learning of mathematics with technologies*

Working in a community is one of the competences requested by society in these years and teachers are not already used to do it, not only face-to-face, but also at distance.

**Project description**

How can a community grow, maintain active and interactive through the use of communication and representation infrastructures?

What are the core activities in a teachers' community working in a lifelong learning program?

What is the impact these activities may have on teachers' professional improvements and their practice in the classroom?

What are the consequences of this kind of experience made by the teachers in communities on their students' learning processes?

**Project partners**

Educators, policy makers (ministry of education), researchers

**Project justification**

The development of collective leaderships in a school or networks of schools is an important goal of our society. The collaboration between research, institutions and policy makers is necessary.

The entire set of 311 project proposals is available online on the [STELLAR homepage at University of Freiburg](#).

Figure 18 illustrates the distribution of the project proposals among the 11 Core Research Areas. The bar graphs are ordered by number of project proposals. The number of research projects that were proposed for each CRA could be interpreted as a behavioral measure of the CRA's importance for TEL research. In this sense, the experts' choice of a CRA for proposing a research project complements the experts' ranking of the CRAs. We pursued this line of analysis and related the ranking of the CRAs to the number of project proposals for each CRA. When comparing the overall rank order of the CRAs to the order of the CRAs by number of project proposals, we detected that the same four CRAs (*reducing the digital divide, workplace learning, informal learning, and interoperability*) fall short in the number of proposed research projects compared to the rank order of the CRAs. When comparing the groups of experts, educators proposed the most projects for the same CRA (*improve practices in formal education*) that they had ranked higher than the other experts.

Taken together, the results of the ranking of the Core Research Areas and the number of project proposals suggested for each Core Research Area draw a very similar picture. These results should enable funding agencies on the national and European level to make informed decisions about relevant priority programs for research on TEL.

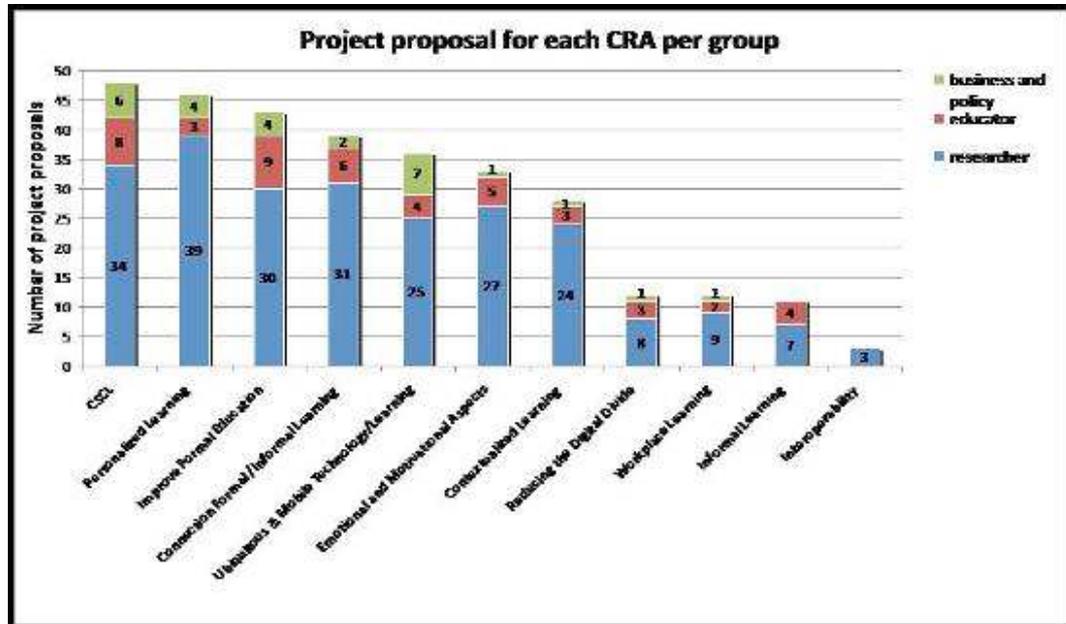


Figure 18. Number of project proposals for each Core Research Area per group.

In a second step of the analysis of the data for the CRAs, we aimed at providing a pool of research topics to the Core Research Areas. We identified project proposals posing relevant and innovate research questions and developed Grand Challenge Problems by combining several of these research project

proposals. We will describe this process in the following chapter and present five Grand Challenge Problems based on the Delphi results.

### **3.5 Elaboration of Grand Challenge Problems**

In the final Delphi round, we aim at sharing the results of the STELLAR Delphi study not only beyond the STELLAR network but also within the network. In this process, the research project proposals provide an opportunity to contribute additional Grand Challenge Problems from another instrument to the existing pool of Grand Challenge Problems that were generated e.g. at the Alpine-Rendez-Vous in LaClusaz in 2011.

As mentioned above, the panel of experts contributed 311 project proposals for the 11 Core Research Areas with a varying number of project proposals generated per Core Research Areas (see Figure 18). One goal of the analysis of the research project proposals was to identify Grand Challenge Problems. A Grand Challenge Problem should foster scientific and technological innovation to solve key problems in TEL and should further be understandable and significant, with a clearly stated compelling case for contributing to long-term benefits for society. The Grand Challenge Problems that have been identified so far within the work of the STELLAR network (e.g., at the Alpine Rendez-Vous 2011) were developed in a top-down process starting with an issue or problem that the TEL community is facing. Then, the experts drew upon their individual experiences and knowledge for adding concrete research activities to the overall Grand Challenge Problem.

In return, we combined the most innovative, interesting and relevant project proposals for each Core Research Area and thereof extracted Grand Challenges Problems. In this way, we developed the Grand Challenge Problems in a bottom-up process, starting with fine-grained research project proposals and thereof extracting comprehensive research themes, that is, Grand Challenge Problems. We underpinned each Grand Challenge Problem with the according project proposals and the relevant set research questions to be addressed.

For illustrating this process of extracting Grand Challenge Problems from the Delphi results, we are next presenting the elaboration of five exemplary Grand Challenge Problems. The entire set of Grand Challenge Problems that will be identified out of the STELLAR Delphi study results will be presented in D1.8 – the final TEL Grand Challenge Vision and Strategy Report.

#### **Grand Challenge Problem 1: CSCL in teacher training and professional development**

We selected three project proposals for the Core Research Area *computer-supported collaborative learning* that were grouped under the theme “teaching and CSCL” and integrated them into the exemplary Grand Challenge Problem “CSCL in

teacher training and professional development“ (see below). The original project proposals as written by the experts are given below.

## **CRA Computer-supported collaborative learning**

### **Grand Challenge Problem1: CSCL in teacher training and professional development**

*What problems of the European education system are addressed, and what are the long term benefits for society?*

In order to foster computer-supported collaborative learning (CSCL) in classrooms, teachers have to develop professional practices for implementing various types of CSCL activities with ease and confidence. It is known that a teacher's own learning experiences are reflected in his/her teaching style; therefore, teacher education has to be renewed to include new teaching methods such as CSCL with teachers as active learners. In addition, continuous professional teacher development could benefit from networked teachers who form a community of practice and build and share professional knowledge. CSCL bears the potential to enhance teachers' pedagogical and content knowledge and to increase teachers' ability for creative problem-solving. Collaborative learning spaces like wikis and other social networking tools hold much promise for supporting ongoing reflective practice and teacher learning because they make teaching practices and reflection visible in ways that have not been possible before.

*What are the main activities to address this Grand Challenge Problem?*

When implementing changes to the teacher education curriculum and the professional development of teachers, the following research questions/issues have to be investigated:

- What methods can we use to ensure that professionals in education have face to face and digital opportunities to share their knowledge collaboratively and build new theory and practice in learning?
- How can a community of teachers grow and remain active through the implementation of CSCL?
- How and to what extent do networked learning environments enhance technological, pedagogical, and content knowledge for teachers?
- How might this spark innovation, creativity, and high level problem solving and solving in the classroom?
- What is the impact these activities may have on teachers' expertise and their professional practices in classroom?
- What is the impact of increased CSCL learning experiences made by teachers in networked communities on their students' learning?

The renewed teacher education curriculum has to be monitored for difficulties and barriers (formative evaluation) and evaluated against the professional standards that the teachers in training have to reach (summative evaluation).

*What is the timeframe for the Grand Challenge Problem?*

In order to integrate CSCL into teacher education and professional development on a large-scale, a joint effort of researchers, teacher educators, and the national Ministry of Education in several European countries is needed; therefore, the timeframe is 10 years.

*What are measurable progress and success indicators?*

The clarification of the research questions and the monitoring of difficulties in the networked community is a first step towards solving this GCP. The teachers' level of activity in the CSCL environments should be monitored and the quality of interaction in terms of higher order problem-solving should be evaluated.

Additionally, the changes in teacher education and teachers' continuous professional development should be reflected in the quality of their teaching practice concerning the successful integration and execution of CSCL-activities in the lesson plans.

*How can funding be attracted?*

European research project funded under the European Commission. In order to ensure the close link between research and practice, the applying institutions should be required to commit to a working partnership with the national Ministry of Education. Thereby, the implementation of CSCL in the actual teacher education curriculum and the professional development can be guaranteed and investigated.

## Research Project Proposals associated with this Grand Challenge Problem

### Project title

*Making Teaching Visible (MTV): Networked Learning Environments for Teacher Learning*  
University of West Virginia, College of Human Resources & Education West Virginia Department of Education

### Project description

How and to what extent do networked learning environments enhance technological, pedagogical, and content knowledge for teachers? How might this spark innovation, creativity, and high level problem forming and solving in the classroom?

Collaborative learning spaces like wikis and other social networking tools hold much promise for supporting ongoing reflective practice and teacher learning because they make teaching practices and reflection visible in ways that have not been possible before. However, that promise has often not come to fruition. We suggest a new model of teacher professional development that uses online communication and collaboration tools (in context, connected to teacher needs and school missions) to make teacher learning visible through digital media and professional learning networks that is directly connected to teacher learning goals. Teachers in an earlier study moved from being "lurkers" by visiting other teachers' wikis and quietly gathering ideas to being active participants who created tutorials and other materials to share with the group.

### Project justification

Teachers who learn how to effectively leverage professional learning communities through advancing their digital literacy skills across an array of digital media and virtually leaving the classroom door open are better able to translate those skills into student-centered classroom practice. This is a critical step in helping teachers develop professional practices that are likely to get us to classrooms that are a central part of networked learning spaces for learners that are not limited to four walls, but only by our own imaginations

### Project title

*Encouraging the collaborative building, sharing and dissemination of professional knowledge*

### Project description

What methods can we use to ensure that professionals in education have face to face and digital opportunities to share their knowledge collaboratively and build new theory and practice in learning?

### Project justification

There is a need for teachers to become activist professionals (Sachs 2003) publishing practice based research with and for other teachers, especially if they are to be kept in their school for their professional training in the future.

### Project title

*Communities of practice in teaching/learning of mathematics with technologies*  
*Working in a community is one of the competences requested by society in these years and teachers are not already used to do it, not only face-to-face, but also at distance.*

### Project description

How can a community grow, maintain active and interactive through the use of communication and representation infrastructures?

What are the core activities in a teachers' community working in a lifelong learning program?

What is the impact these activities may have on teachers' professional improvements and their practice in the classroom?

What are the consequences of this kind of experience made by the teachers in communities on their students' learning processes?

### Project justification

The development of collective leaderships in a school or networks of schools is an important goal of our society. The collaboration between research, institutions and policy makers is necessary.

## **CRA Ubiquitous & mobile learning and technology**

### **Grand Challenge Problem 2: Mobile augmented reality in health care training**

*What problems of the European education system are addressed, and what are the long term benefits for society?*

The daily work practices in health care and medicine require skills for imagining physical processes that are invisible to the human eye. Modern technologies, such as smart phones, can be used for visualizing the hidden processes through creating an augmented-reality (AR), a virtual, visual layer on top of the actual captured images. Medical practitioners, nurses, or students could view and experience former imperceptible medical procedures and create richer representations and deeper understanding of bio-physiological mechanisms. In the long-run, the integration of AR in medical and health care practices might lower error rates in diagnosis and treatments. In addition, the delivery of AR on mobile devices offers the possibility to transfer high-tech simulations and scenarios to remote or less developed regions in the world.

*What are the main activities to address this Grand Challenge Problem?*

For developing a mobile AR tool for medical and health practices, a multidisciplinary team should base their work on the extended corpus of research within the field of mobile learning, health care training and visualization programming:

- Which medical tasks are appropriate and suitable to be visualized?
- Which support structures (content, pedagogy, contextualization) are needed by learners and practitioners to use the tool successfully?
- Can the mobile AR tool be designed for satisfying the needs of learners and practitioners at the same time?
- Which are the essential technical requirements the mobile device has to meet?

In the implementation/evaluation phase, the usability of the mobile AR tool and its adoption in real-life settings should be investigated.

In order to facilitate integration and distributing of the mobile AR tool in countries around the world, a mixed-method study (incorporating ethnographic research perspectives) which reveals differences as well as similarities in using and learning with the tool within multiple cultures:

- What are the human factors contributing to or limiting the up-take of ubiquitous and mobile learning tools such as the mobile AR tool within healthcare training?
- Will lesser developed regions adopt the mobile AR tool in healthcare training and medicine and will AR scenarios increase the overall access to health services?

*What is the timeframe for the Grand Challenge Problem?*

In order to develop and evaluate AR tools for health care training and professional development in medicine, a joint effort of researchers, medical practitioners, and technology developers is needed; therefore, the timeframe is 10 years.

*What are measurable progress and success indicators?*

This GCP involves the following milestones: analysis of medical tasks and writing of software script, development of educational software tool, evaluation of tool in

laboratory and real-life settings. Implementation and evaluation of AR tool in hospitals and medical practices in several European countries.

*How can funding be attracted?*

European research project funded under the European Commission. In order to ensure the evaluation of the AR tool in real-life settings, the applying research institutions should be required to commit to partnerships with a hospital and several medical practices.

## **Research Project Proposals associated with this Grand Challenge Problem**

### **Project title**

*Pervasive Learning in Healthcare: Forecasting the Future of Learning within an Age of Ubiquitous Communication in Healthcare and Medicine*

### **Project description**

What are the human factors "contributing" to the up-take of ubiquitous and mobile learning within healthcare and medicine?

What are the human factors "limiting" to the up-take of ubiquitous and mobile learning within healthcare and medicine?

Are lesser developed regions more likely to adopt and adapt to current and emerging ubiquitous and mobile learning cultures within healthcare and medicine?

Will ubiquitous and mobile learning scenarios increase access to healthcare and medicine?

### **Project justification**

- To extend the corpus of research within the field of mobile learning;
- To develop innovative methods to observe behaviours surrounding current and emerging communication cultures;
- To conduct a mixed-methodological study which provides a solid forecast of individual and collaborative learning cultures influenced by ubiquitous computing / communications based upon ethnographic research;
- To chronicle and present seven years of ethnographic field research observing the changes in communication and learning cultures;
- To help inform policy makers of current and emerging trends in ubiquitous communication and pervasive learning cultures and scenarios

### **Project title**

*Mobile and 3D technologies for contextual and pervasive learning*

### **Project description**

See justification.

### **Project justification**

Recent longitudinal studies in medical education reveal that 3D visualization has produced significantly better learning and patient diagnostic outcomes (49% in Emory Univ study on breast cancer detection modules). Leveraging this in a lower cost, more readily available mobile platform could lead to significant cost savings, medical outcomes and learning outcomes.

### **Project title**

*Mobile Virtual and Remote Labs*

### **Project description**

Improve the technology and pedagogy of accessing labs via mobile devices.

### **Project justification**

Wide use of the mobile technology amongst young generations at low cost.

## CRA Improve practices of formal education

### **Grand Challenge Problem 3: Acquisition of graphical and digital literacies through teaching with ICTs**

*What problems of the European education system are addressed, and what are the long term benefits for society?*

We live in a digital world that demands new skills and literacies. Being 'literate' in today's society has wider implications beyond typographic text. With new and varied means of communicating available through the existence of ICTs, there is a need to develop more understanding into the way in which people construct and interpret multimodal texts. Students are increasingly exposed to an ever-widening array of graphical representations (data visualizations, hybrid text and graphical combinations, graphical representations of text (word clouds) to name but a few). Diagrams and other graphics also cross cultural and linguistic boundaries - another facet of their importance. Graphical literacy is crucial for all STEM domains and as interactive graphical systems become ever more ubiquitous students must be equipped to exploit them for their own applications.

Taken together, students' digital literacy skills require increasing 'graphical literacy' or graphicacy as well as literacy. Yet there is very little direct instruction in the selection, creation, and application of diagrams - at least not in a subject independent way akin to 'languages' as subjects. And even in the language subjects, the skills for dealing with multimodal texts are scarcely taught.

*What are the main activities to address this Grand Challenge Problem?*

First, we need a better understanding of how students acquire graphicacy skills and common graphical misconceptions (e.g. 'graph as picture') as well as how to best teach students effective principles for assigning particular representational forms to educational contexts and problems i.e. what some researchers have termed the 'applicability conditions' for selecting, say, tables or network diagrams or hierarchical graphs, set diagrams, and so on. Additionally, further examination is required into the way in which students 'read' multimodal texts and the way in which such texts can be integrated into the formal educational context.

In a second step, multimodal texts and graphical teaching materials have to be designed. These study material should be based on the implications for formal literacy education that were revealed in the research advances described above.

*What is the timeframe for the Grand Challenge Problem?*

A joint effort of researchers, literacy and STEM teachers, software designers, and the national Ministry of Education in several European countries is needed; therefore, the timeframe is 10 years.

*What are measurable progress and success indicators?*

The clarification of the skills students acquire for deciphering multimodal texts and complex graphical representations is the first step towards solving this GCP. The cognitive processes that are relevant for learning with multimodal texts and multiple graphical representations should be described in an empirically-tested model or theory.

The second step is the creation of teaching/studying materials based on the identified cognitive processes. In this step, software designers have to overcome technical difficulties in the design process.

*How can funding be attracted?*

European research project funded under the European Commission. In order to ensure the close link between research and practice, the applying institutions should be required to commit to a working partnership with their national Ministry of Education for updating the curricula to include graphical literacy and the appropriate teaching material.

## **Research Project Proposals associated with this Grand Challenge Problem**

### **Project title**

*Teaching Students 21st Century Skills: What Should Education Look Like Today?*

### **Project description**

What does our current approach to education look like (theories and method)?

What do students want from education (do they want to learn, do they just want a piece of paper, do they want generic skills)?

What do employers want from education (students with knowledge, students with IT skills, students with people skills)?

### **Project justification**

New technologies have fundamentally changed the way that we are in the world and they effect us in every area of our lives. At the same time the world itself has fundamentally changed. We live in with a global economy that demands new attributes and skills. It is not clear that the education system has changed to meet the requirements of students or employers. This research project would generate findings that could inform an approach to teaching and learning to meet student and employer needs.

### **Project title**

*Exploiting TEL to improve students' graphical literacy*

### **Project description**

Traditional curricula strongly emphasise linguistic literacy, indeed 'English' is a subject in its own right in the UK and USA. However in the digital world in general and TEL in particular, students are increasingly exposed to an ever-widening array of graphical representations (data visualisations, hybrid text and graphical combinations, graphical representations of text (word clouds) to name but a few). One form of graphical representation, diagrams, is particularly useful for problem solving in many formal domains. Students' digital communication skills require

increasing 'graphical literacy' or graphicacy as well as literacy. Yet there is very little direct instruction in the selection, creation, and application of diagrams - at least not in a subject independent way akin to 'English' as a subject. Diagrams and other graphics also cross cultural and linguistic boundaries - another facet of their importance. My proposal involves providing students with TEL environments which offer multiple representations for problem solving and which supports students as they acquire the skills of matching and selecting right representations for the task at hand, the right representation for them (i.e. one that's in their current repertoire). The support involves teaching principles of assigning representations to tasks based on the semantic and cognitive properties of various graphics, and which scaffolds students in the process of diagram construction.

### **Project justification**

Much more research is required on individual differences in graphicacy beyond the simplistic visualiser-verbaliser 'learning styles' approaches. Basic research on how students acquire graphicacy skills and common graphical misconceptions (e.g. 'graph as picture') is required. Research is also needed on how best to teach students effective principles for assigning particular representational forms to educational contexts and problems i.e. what some researchers have termed the 'applicability conditions' for selecting, say, tables or network diagrams or hierarchical graphs, set diagrams, and so on. Any professional statistician, engineer, archaeologist, mathematician,

computer scientist will attest to the importance of non-linguistic forms of external representation for reasoning and communication! Graphical literacy is crucial for all STEM domains and as interactive graphical systems become ever more ubiquitous students must be equipped to exploit them for their own applications. It is also crucial that students are sufficiently 'graphically literate' that they can interpret complex graphical visualisations produced by others and to be able to spot graphical 'lies' e.g. in statistical graphs and charts.

### **Project title**

*New literacies, new texts in the formal educational context*

### **Project description**

The developing range and variety of interactive multimedia narratives (e.g. computer games) available within the home context have not yet made a similar impact within the school context. In order to empower children as critical readers of a wide range of literature, further examination is required into the way in which children 'read' such texts and the way in which such texts are integrated into the formal educational context.

How do children 'read' multimodal texts?

What are the implications for formal literacy education?

How might such texts be designed and integrated into the school setting?

### **Project justification**

With new and varied means of communicating available through the existence of ICTs, there is a need to develop more understanding into the way in which people construct and interpret multimodal texts. Allowing children opportunities to become critical consumers of the growing array of interactive multimodal texts would respond to this. Being 'literate' in today's society has wider implications beyond typographic text and the range and variety of suitable texts within the primary classroom needs to be developed. This presents some challenges to software/hardware designers to create texts which are relevant to the context and the purpose.

## CRA Emotional and Motivational Aspects of TEL

### **Grand Challenge Problem 4: Increasing student motivation to learn and engaging the disengaged**

*What problems of the European education system are addressed, and what are the long term benefits for society?*

What if school was optional? What if educators, researchers, and parents couldn't rely on school being compulsory and had to make it a different kind of place? Even though school will probably remain compulsory in the future; we should start addressing the issues at hand: how can we increase student motivation to learn and how can we integrate disengaged students?

Indicators for the increasing number of unmotivated students are high attrition rates and low interest in school, especially in STEM subjects. Debates about academic achievement often focus on cognitive aspects and neglect the role motivation plays in it. In general, the importance of intrinsic motivation isn't new, but the education systems around the world should get on board quickly and should aim to make learning personally rewarding and valuable for every student. Technology could be a useful instrument for providing learning experiences that meet those goals. It could provide tools to educators, researchers, parents, and learners that enable self-directed learning driven by need for mastery.

*What are the main activities to address this Grand Challenge Problem?*

In order to examine the potential of TEL for increasing students' motivation, the following research questions should be investigated:

- What are the factors in technology-enhanced learning environments promoting self-directed and intrinsically motivated learners?
- Extrinsic rewards have been shown to impede intrinsic motivation. How can technology offer alternatives to standardized testing and extrinsic/conditional rewards for good performance?
- Are there individual aspects that moderate the effect of TEL on motivation such as affinity to computer games or ICT in general, social background/social status, etc.?
- How can technology related to learning in school promote self realization, self expression, and identity formation?
- Could technology help to make students' productive activities outside of the school context more accountable in school and how would that affect students' perception of such activities?

While enabling students to be intrinsically motivated learners, we should not forget those students who are unmotivated and disengaged from learning as a whole:

- How to identify disengaged and unmotivated learners? How can they be re-engaged in the learning process?
- How can we identify differentiate states of demotivation and unmotivation?
- How can we remediate these different kinds of states in a way that improves the situation and causes minimal negative side-effects?

### *What is the timeframe for the Grand Challenge Problem?*

The thorough investigation of the research questions posed above necessitates the cooperation of researcher (experts in motivation, serious games, didactics, software design) and practitioners (teachers, students, parents, educators outside of formal learning) from several European countries; therefore, the timeframe is 10 years.

### *What are measurable progress and success indicators?*

The investigation of the research questions should reveal possible actions to be taken for increasing students' motivation to learn. Even further, strategies for engaging unmotivated students should be outlined and tested.

Overall, the implementation of adequate technology-enhanced learning environments should lead to measurable increases in student motivation and in a second step increase academic achievements.

### *How can funding be attracted?*

European research project funded under the European Commission. In order to ensure the cooperation between research and practice, the applying institutions should represent experts in motivation as well as educational technology experts and also should be required to commit to a working partnership with schools and educational institutions outside of formal learning settings.

## **Research Project Proposals associated with this Grand Challenge Problem**

### **Project title**

*Intrinsic motivation: Helping education create learners that the world needs*

### **Project description**

Technology has provided some of the best examples of the power of intrinsic motivation: Wikipedia was created by millions in their spare time. Linux powers many of the servers at large companies in the world. Gmail and Google maps come from the 20% rule at Google - a system that allows workers to work on whatever they want for 1 day a week. It creates autonomy, it provides purpose, and it is driven by the desire for mastery. Intrinsic motivation isn't new, but the world has never really been ready for it. As examples like Google demonstrate, this is changing, and the education systems around the world should get on board quickly.

What role do technology-based learning environments play in promoting self-directed and intrinsically motivated learners?

How can technology help overcome the addiction that exists for standardized testing and conditional rewards for good performance?

What are the real survival skills that will be needed in 2020 and beyond?

### **Project justification**

What if school was optional? What if educators, researchers, parents, and all adults couldn't rely on school being compulsory and had to make it a different kind of place? What would happen? What would they rely on to fill up the school with eager learning?

My guess is that they would work to make it something personally rewarding and valuable for every student. They (we) would need to work very hard to understand their needs, desires, wants and to provide experiences that met those goals.

Technology would play a vital role in this change. It would provide tools to educators, researchers, and parents that could be used to persuade kids of the value of school. It would (and does) allow them to connect socially, share, collaborate, and more. The goal of this project would be to inspire a global change in educational practices so that learners would finish school ready for a world that needed them yesterday.

**Project title**

*Factors supporting intrinsic motivation for technology-enhanced learning*

**Project description**

What are the factors that support intrinsic motivation for technology-enhanced learning?

Dependent variable: intrinsic motivation

Independent variables: affinity to computer games or other computer issues, learning environment, personal situation, social background/social status, etc.

**Project justification**

-

**Project title**

*Role of technology in increasing the student-perceived value of academic content*

**Project description**

Value perceptions need to be 'educated'; there is no intrinsic reason why a 16 year old girl, say, should find matrix algebra valuable to invest effort in. General achievement motivation is not sufficient (for most). The big challenge for teachers/schools is to help students experience the value of such cultural tools; teachers/schools fail most of the time (not their fault in many cases, but we need somebody to blame). We know that to appreciate the value of abstract concepts/tools/ideas, they need to be related to self realization, self expression, identity formation. How can technology help in this? For instance, can it help to make students' productive activities outside of the school context more accountable in school? How does it affect students' perception of such activities? Etc.

**Project justification**

Well, in most motivational models we have Expectancy \* Value, and if V gets close to zero, we are in trouble. And more specifically, all those findings showing the loss of interest in math, science, technology, engineering, ...

**Project title**

*Adaptation to Motivation in TEL*

**Project description**

How to identify dis-engaged and unmotivated learners? How can they be re-engaged in the learning process?

**Project justification**

Motivation is one of the most important factors for learning. We still see rather high attrition rates. This project has the potential to make different forms of TEL much more efficient.

**Project title**

*Developing pedagogies for the unmotivated and the demotivated*

**Project description**

1. How can we identify different kinds of states of demotivation and unmotivation.
2. How can we remediate these different kinds of states in a way that improves the situation and causes minimal negative side-effects?

**Project justification**

Without the motivation to expend intellectual and emotional effort in learning, the learner does not progress. Motivation is key. Finding ways to help learners be more productive will help make better use of the huge sums currently spend on education.

## **CRA Connection between Formal and Informal Learning**

### **Grand Challenge Problem 5: Bridging informal and formal contexts to create a unified learning landscape**

*What problems of the European education system are addressed, and what are the long term benefits for society?*

In today's knowledge society, we come across learning opportunities literally around every corner. Mobile devices and other technological innovations have changed the basic conditions for learning and introduced new learning spaces in everyday life and, to a lesser extent, in formal (schools) and informal (museums) learning institutions.

The resources that especially young people use for learning and constructing knowledge can be characterized by mobility and multiplicity – ubiquitous access to multiple resources for information. This means that schools are not the only privileged source of knowledge; young people participate and learn in a broad range of contexts and have to translate/transform knowledge between these spaces. This characteristic of today's learning landscape leads to an interconnectedness or divide between student learning inside and outside the formal classroom. With this gap between youth cultures of learning and school education that students often perceive and feel, there is a lot of lost and missed opportunities for engaging and enriching learners.

Research is needed that explores how learners translate and transform knowledge between contexts, with a particular focus on technologies that support learning across school and informal learning settings.

*What are the main activities to address this Grand Challenge Problem?*

First of all, we need to better comprehend the characteristics of how students connect learning between contexts, especially between school and informal learning settings. A theoretical framework addressing the following research questions should be build based on empirical evidence:

- What are students learning outside the formal classroom?
- Which technologies are used and how are they used?
- What are the cognitive, emotional and motivational processes when learning in informal learning contexts as opposed to learning in the formal classroom?
- How is learning shaped by the purposes to which knowledge and understanding are put?
- Where are the connections between what students are learning inside the formal classroom and what they are learning outside the classroom? How do they translate/transform knowledge between those contexts?

In a second step, we should explore and evaluate possibilities for facilitating, that is orchestrating, the translation of knowledge between informal and formal contexts for ultimately creating a unified learning landscape:

- How can technologies that have been identified to be used in informal learning settings be emulated within classroom contexts?
- How can we orchestrate learning within and between spaces of different nature: Web, 3D virtual and augmented physical spaces?

- How can we enable the flow of activity state and data between spaces, and the linking of objects in different spaces, so that orchestration can be achieved?

*What is the timeframe for the Grand Challenge Problem?*

Researchers specializing in formal learning as well as informal learning should work together with practitioners in both learning contexts (e.g. teachers, pedagogical staff in museums, etc.) for investigating the research questions presented above. Even further, the national Ministry of Education in several European countries should be involved for implementing the findings in the national school curricula and teaching practices; therefore, the timeframe is 10-15 years.

*What are measurable progress and success indicators?*

After completion of the first step, a comprehensive framework describing the interconnectedness of learning in formal and informal settings should be created. The second step towards addressing this Grand Challenge Problem should result in the implementation of facilitating technologies/teaching practices for bridging formal and informal learning into school education.

*How can funding be attracted?*

European research project funded under the European Commission. The applying institutions should represent both formal and informal learning institutions in order for the research project to reflect the close link between both learning spaces. In addition, the national Ministries of Education should be supporting the research proposals and be willing to appoint project schools for implementing/investigating the presented research questions.

## **Research Project Proposals associated with this Grand Challenge Problem**

### **Project title**

*BRIDGES*

### **Project description**

Mobile devices and other technological innovations have changed the basic conditions for human learning and introduced new practices to everyday life and, to a lesser extent, formal (schools) and informal (museums) learning institutions. The resources that young people use for learning and constructing knowledge can be characterized by mobility and multiplicity - ubiquitous access to multiple texts, resources and representations. This means that in today's society, schools are not the only privileged source of information; young people participate and learn in a broad range of contexts and settings, e.g., play, computer games, museums, home. As participants move between activities, they develop specific skills for each activity, as well as some generic (general) skills.

This project explores how participants translate and transform knowledge between contexts, with a particular focus on technologies that support learning across school, museum and home settings. One of the aims of this research is to inform reforms in teacher education.

### **Project justification**

The education sector is facing demanding challenges in coming years. Studies exploring future development of education and technology suggest a continuing shift towards a more diverse and complex learning landscape where learning takes place across a wide range of sites and institutions. This development is due in part to mobile devices and socio-technical networks, which are an increasingly central means of gaining, sharing and generating knowledge across institutional boundaries. Present reform initiatives surrounding teaching and learning are not sufficiently preparing student teachers to meet these changes, as teacher education programs are based on training and coaching models that focus mainly on developing a repertoire of classroom practices. One means of bridging formal and informal learning settings is the design and use of new

technologies and media to enhance teaching and learning. BRIDGES addresses these societal challenges in the education sector through interdisciplinary collaboration in a project that is organized with research experts from the fields of TEL, teacher education, and museum learning.

### **Project title**

*Digital Cultures and Education. Methodological hypothesis and technological solutions for teaching and learning merging, between formal and informal situations*

### **Project description**

The research program aims to detect the relationship between formal and informal learning, paying particular attention to media consumption, reception practices and utilization in order to bridge the gap between youth cultures and school education. Digital convergence leads to new modalities in culture appropriation and utilization in order to bridge the gap between youth cultures and school education. Digital convergence leads to new modalities in culture appropriation and knowledge skills, enabling contemporary generations to a more dynamic and creative approach.

### **RESEARCH QUESTIONS**

The research moves from two main questions that research in education already put in evidence about digital and social media, that is:

- 1) the need of clarifying how individuals construct their own knowledge in informal settings;
- 2) the determination of the role media play for that in relation to current consumption opportunities.

Since the convergence between formal and informal contexts is promoting personalized processes, we have to find out new teaching methods to promote the activation of these processes it selves.

### **AIMS**

Research makes sense of to two main aims:

- 1) a first category includes detection, recognition and reconstruction of the theoretical framework about the analysis of three dimensions concerning youth media consumption: public, participation e learning;
- 2) the second one includes preparation, planning guidelines, methodologies, cultural and technological artifacts in order to facilitate a meaningful and appropriate use of technology in education.

### **OUTCOMES**

The research will produce the following outcomes:

- monitoring of case studies to detect the gap between youth cultures and school ones;
- design, implementation and realization of technological solutions to facilitate the merging of technologies;
- drawing of guidelines to implement sustainable teaching practices;
- building of a glossary as an ontological frame of research;
- media practices analysis of students and teachers in formal and informal contexts.

### **Project justification**

-

### **Project title**

*The Interconnectedness or Divide between Student Learning Inside and Outside the Formal Classroom*

### **Project description**

1. What are students learning outside the formal classroom and how are they learning? How much time do they spend with technology and what do they do with it?
2. Is there any connection between what students are learning inside the formal classroom and what they are learning outside the classroom? How are they making those connections? How much transfer of learning exists between contexts?
3. Is the cognitive process the same or different when learning in the formal classroom and informal learning?

### **Project justification**

The potential of technology is often cited as being able to transform education and that it is already changing the way students learn. It is important to describe, measure and evaluate that learning

both in a formal setting (where the majority of children spend a great deal of time) and in informal settings (where children have access to and are using new technologies). Children are spending more and more time engaged in technological activities without any measure of what they are learning or how.

### **Project title**

*Orchestrating formal and informal learning activities in physical and virtual spaces*

#### **Project description**

Objectives:

1. To define a framework for the orchestration of educational settings within and between reflected spaces of different nature: Web, 3D virtual and augmented physical spaces.
2. To provide technological components that enable the flow of activity state and data between spaces, and the linking of objects in different spaces, so that orchestration can be achieved.
3. To define methods and supporting technology for the evaluation of ubiquitous learning that take into account the actions of the learners in the different spaces
4. To design, implement and evaluate pilot experiences using orchestrated elements in reflected spaces

#### **Project justification**

Nowadays education does not happen exclusively face-to-face, in the physical space. Neither does it happen exclusively through online tools, like VLEs, blogs or wikis. There is a continuous transfer from one space to another: certain activities are done in the classroom, then some are accessed on a web virtual learning environment or 3D world, then the students collaborate either physically or digitally...

Orchestrating the learning activities is a complex task that involves the design, support, observation and on-the-fly adaptation of the whole learning process. This process consists of several activities in which learners interact with physical or digital objects, by producing, consuming or annotating them....

### **Project title**

*Enabling seamless learning*

#### **Project description**

How to bridge formal learning and informal learning from the learner perspective? I.e. connecting the formal learning that happens in the classroom to all aspects of informal learning, and vice versa, with the goal of engaging and enriching learning experiences

#### **Project justification**

With the disconnect that learners perceive and feel between what they do in formal learning situations and what they do in informal learning situations, there is a lot of lost and miss opportunities for engaging and enriching learners. Research is needed to look at a host of issues from a systemic perspective (curriculum design, assessment practices, professional development, technology support, parental support, ...).

In sum, we are developing additional Grand Challenge Problems from the research project proposal generated by the international panel of experts in the 4<sup>th</sup> STELLAR Delphi round. These Grand Challenge Problems will be further elaborated and integrated with the Grand Challenge Problems from the Alpine Rendez-Vous at the workpackage 1 taskforce meeting in London in January 2012. The final STELLAR Grand Challenge Problems and the additional Grand Challenge Problems resulting from the Delphi study will be published in D1.8.

## **4 Dissemination of STELLAR Delphi Study Results – 5<sup>th</sup> STELLAR Delphi Round**

The 5<sup>th</sup> and final Delphi round aims at further elaborating the results of the final global survey within the STELLAR network and at disseminating the results of the STELLAR Delphi study beyond the STELLAR network. We present the latter in the next section and described one way of elaborating the Delphi results, that is the development of Grand Challenge Problems, in the previous chapter 3.5.

Our dissemination plan includes the strategic use of STELLAR instruments for spreading the results of the STELLAR Delphi study amongst researchers and stakeholder of the wider TEL community. For involving stakeholders in this communicative process, the Core Research Areas and Areas of Tension were presented to and discussed with stakeholders in workshops at the EDEN conference 2011 and the EFQUEL INNOVATION FORUM 2011 in close cooperation with workpackage 5 representatives. In order to reach young talents in the scientific sector, we incorporated sessions on the Delphi results at several doctoral schools such as the JTEL winter school 2011 that was hosted jointly with the STELLAR Alpine-Rendez-Vous 2011 in LaClusaz and asked the participants of the JTEL summer school 2011 in Crete to position their research in relation to the Core Research Areas and to identify additional Areas of Tension. In the remaining time of the STELLAR project we further plan to contribute another STELLAR Delphi briefing that illustrates the main findings of the STELLAR Delphi study in a concise format.

Our strategy for disseminating the results of the Delphi study within the scientific community encompasses the presentation of the Delphi results at conferences (CSCL 2011, CAL 2011, ICCE 2010) and the publication of two journal papers that are in preparation and will be submitted to peer-reviewed journals soon. One paper addresses the Areas of Tension (Plesch et al., submitted) and the second presents the Core Research Areas (Plesch et al., in preparation). The planned publication on the Core Research Areas will relate the presented finding to existing forecasting studies such as the most recent Horizon Report (Johnson, Smith, Willis, Levine, & Haywood, 2011), the National Educational Technology Plan of the US Department of Education (2010), and the work of Futurelab (Daanen & Facer, 2007; Facer & Sandford, 2010) which aimed at envisioning future scenarios for education till 2020 while challenging traditional institutional beliefs in education.

## 5 Summary and Conclusions of the STELLAR Delphi Study

In this final report on the STELLAR Delphi study, we presented the results of the final global expert survey (4<sup>th</sup> Delphi round) and described the dissemination and elaboration of these results (5<sup>th</sup> STELLAR Delphi round).

Overall, the STELLAR Delphi study aimed at identifying future themes for TEL research and possible tension within the field TEL and TEL research. This process was designed to incorporate the perspectives of European and global TEL stakeholders and researchers including the STELLAR members. The STELLAR Delphi study was composed of five rounds; two internal rounds (1<sup>st</sup>, and 3<sup>rd</sup> STELLAR Delphi round) that were conducted within the STELLAR network, two large, global survey rounds (2<sup>nd</sup> and 4<sup>th</sup> STELLAR Delphi round) among TEL experts from outside the STELLAR network and the 5<sup>th</sup> STELLAR Delphi round for disseminating the results beyond the STELLAR network. The 1<sup>st</sup> STELLAR Delphi round started in 2009 and the 5<sup>th</sup> and final Delphi round will end in May 2012.

The STELLAR-experts of the 1<sup>st</sup> Delphi round contributed qualitative input concerning future trends in TEL and TEL research, as well as controversial statements about the future of TEL. These contributions provided the basis for the questionnaire of the 2<sup>nd</sup> Delphi round that included future trends TEL research and visionary statements about the future of TEL in general. In the 2<sup>nd</sup> Delphi round, the international experts' evaluation of the future trends indicated that future research in TEL would benefit from a perspective on TEL that integrates all three aspects: relevant societal challenges and demands, influential technological developments, and important research themes. Consequently, the 3<sup>rd</sup> Delphi round served to identify *Core Research Areas* based on the results of the Future Trends. A Core Research Area combines the most relevant research themes, technological developments, and societal challenges. In addition, the experts of the 2<sup>nd</sup> Delphi round rated visionary statements for TEL and revealed conflicting views on certain aspects of TEL and TEL research. These findings led to the identification of *Areas of Tension* in the 3<sup>rd</sup> Delphi round. An Area of Tension presents two opposing views on a certain future development in TEL. In order to dissolve the tension, the TEL-community could capitalize on the synergy effect resulting from integrating both views.

The questionnaire of the 4<sup>th</sup> Delphi round presented the consolidated and elaborated results of the three preceding Delphi rounds – 11 Core Research Areas and 5 Areas of Tension – to 569 international experts. The first part of the questionnaire addressed the following Areas of Tension:

- Area of Tension 1: Data privacy vs. data tracking for personalized learning
- Area of Tension 2: Digital divide despite technology spread
- Area of Tension 3: Focused and critical processing of information vs. ubiquitous learning opportunities
- Area of Tension 4: Approved practices vs. continuous innovation in the classroom
- Area of Tension 5: Standardized vs. individual learning paths

We asked the international panel of experts of the 4<sup>th</sup> Delphi round to position themselves in relation to the two positions on each Area of Tension and to evaluate the future development of the presented tension on several dimensions. Overall, the international experts identified themselves more with positions that emphasized the benefit of implementing technologies in education in opposition to the positions that focused more on the educational aspects of future developments in TEL. This may reveal a blind spot in expert's view on issues of implementation of TEL in the classroom. Not even 60% of teachers integrate ICTs in their instructional practices, even though close to all schools are equipped with ICTs and have Internet access, according to an international study on ICT usage in classrooms in 2006 (Law, Pelgrum, & Plomb, 2008). Despite progress in the research field of TEL, these findings for formal education demonstrate that the translation of research findings into educational practices falls short of expectations.

While the experts overall focused on the benefits of technologies, when their attention was drawn to the underlying tensions described in the AoTs, the experts did recognize that these are significant issues impacting the wider implementation of TEL. Tensions overall were expected to impact the educational sector most. However, experts did expect that the development of strength of tensions could be positively influenced. Practitioners in education and policy-makers were thought to be the actors carrying the most weight for this, followed by researchers and end-users. Finally, through an awareness of tensions and the consequential taking of influence on their development, experts expected that overall the tensions would be reduced in the future.

The second part of the 4<sup>th</sup> STELLAR Delphi round questionnaire was about the Core Research Areas. We asked the experts to rank the 11 Core Research Areas according to their importance for future research programs in TEL in order to provide funding agencies with information on the perspective of the TEL community on future directions for the field. The experts of the 4<sup>th</sup> Delphi round revealed the following order:

1. Connection between formal and informal learning
2. Computer-supported collaborative learning
3. Personalized learning
4. Contextualized learning
5. Ubiquitous & mobile technology/learning
6. Improve practices of formal education
7. Emotional and motivational aspects of learning
8. Informal learning
9. Reducing the digital divide
10. Workplace learning
11. Interoperability

After having ranked the Core Research Areas, the experts were asked to choose one Core Research Area and to sketch a project proposal for a future research projects in this area. The project proposal included a title, research questions/short description, collaborating partners/institutions, and a justification. All in all, the panel of experts contributed 311 project proposals for the 11 Core Research Areas.

These project proposals underpin the rank order with concrete research projects and research questions and that could be help to address problems or issues in the field TEL. We will be analyzing the research project proposals for identifying Grand Challenge Problems for TEL research in the 5<sup>th</sup> STELLAR Delphi round. In this process, we combine those project proposals that are innovative, interesting, and promising into Grand Challenge Problems. In this report, we have presented five Grand Challenge problems that had already been developed (*CSCL in teacher training and professional development; Mobile augmented reality in health care training; Acquisition of graphical and digital literacies through teaching with ICTs; Increasing student motivation to learn and engaging the disengaged; Bridging informal and formal contexts to create a unified learning landscape*); the final set of Grand Challenge Problems based on the Delphi results will be published in D1.8 the final TEL Grand Challenge Vision and Strategy Report. Researchers who are formulating proposals for cooperative research networks may use these Grand Challenge Problems.

Reflecting upon the methodology and implementation of the STELLAR Delphi study, we succeeded in integrating the perspectives of researchers and stakeholders in the five-round study design. Through asking STELLAR members to personally nominate experts and by sending out individualized reminders, we reached a remarkable amount of international experts who shared their expertise in this Delphi study. The interplay between qualitative and quantitative Delphi rounds further enabled deep processing and elaboration of the received input by the global panels of experts.

The most challenging aspect of a Delphi study is the design of the questionnaire that has to reflect the essence of the previous Delphi round results in a concise format. The use of concrete research project proposals in the final global survey proved to be a fruitful approach despite initial concerns about the experts' possible reluctance to share their innovative research ideas. Nearly two thirds of the experts who participated in the final survey contributed a project proposal and shared their visions for future research endeavors in TEL. Out of these research project proposals, a set of Grand Challenge Problems could be identified.

In the process of moderating the experts' co-construction of future visions for the research field of TEL, we introduced the idea of exploring underlying issues by identifying Areas of Tension in the field. The results of the STELLAR Delphi study on the identified Areas of Tension support the usefulness and practicability of introducing this concept in the scientific thinking and reasoning process. Through treating contrary assumptions and visions as two positions in a given field of research that both are valued, one might reveal synergies when the tensions are consolidated or resolved. The adoption of this concept or thinking tool for handling divergent professional opinions on certain aspects in a field of research by many groups of researchers even beyond the STELLAR network is one of the successes of the STELLAR Delphi study.

In conclusion, the findings of the STELLAR Delphi study reveal a great amount of information on future directions and issues that is based on international experts' opinions and visions for the research field of TEL. These findings should attract research on revealed issues in relation to the Areas of Tension and inspire researchers to submit grant proposals to funding agencies to support these activities with national or European priority programs.

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# 7 Appendix

## A Questionnaire of the 4<sup>th</sup> STELLAR Delphi round

[PAGE 1]

**Dear participant,**

**Thank you** for participating in the STELLAR Delphi study. **STELLAR** ([www.stellarnet.eu](http://www.stellarnet.eu)) is a European Network of Excellence with the goal to foster multidisciplinary research in the field of Technology-Enhanced Learning (TEL). The STELLAR Delphi study encompasses several survey rounds – STELLAR internal rounds, and two rounds with a global expert panel – for identifying and exploring expert opinions, visions about future trends and desired developments in TEL and TEL research. The current round is the second and **final global expert survey**; it builds on the results of the previous surveys (for additional information, please visit the [STELLAR Delphi homepage](#)).

You were personally nominated for this last global STELLAR Delphi round based on your expertise in the field of TEL. In this survey we ask you to assess the relevance of Areas of Tension for future research in TEL and to prioritize future Core Research Areas. In addition, please share your expertise by providing input wherever you feel that important points are missing. . You can provide comments in the “general comment” field at the bottom of each page.

Your input in this final survey round is crucial to the finalization of the STELLAR Delphi study. It will help us to shape a catalogue of evidence-based recommendations for future TEL research themes that can inform funding agencies concerning their investments in TEL and future TEL research.

The survey consists of three parts and will take 20 to 30 minutes to complete. **You can move back and forth within the survey using the "back" and "next" buttons** at the bottom of each screen. If you have cookies activated, your session will be saved for 24 hours and you can resume the questionnaire within this timeframe, you can even close the browser window. Without cookies, closing the browser window will end your session. To answer the survey, JavaScript is needed.

If you have any questions, please contact Christine Plesch from the Freiburg Delphi Team ([Christine.Plesch@psychologie.uni-freiburg.de](mailto:Christine.Plesch@psychologie.uni-freiburg.de)).

Best regards,

The STELLAR Delphi Team

(Hans Spada, Nikol Rummel, Anne Deiglmayr, Dejana Mullins, Christine Plesch, and Celia Kaendler)

[PAGE 2]

**Part I: Personal information**

For an analysis of the expert panel, we would like to collect a brief description of each participant's background. Your answers will be analyzed anonymously; however we would be happy to receive your name in order to include it in the list of expert participants, which will be published after the completion of the survey.

Name: \_\_\_\_\_

Affiliation: \_\_\_\_\_

Country: \_\_\_\_\_

**Academic title / highest degree of education:**

- Bachelor
- Master / Dipl.
- PhD / Dr.
- Prof.
- Other: \_\_\_\_\_

**Which group do you belong to?**

Please check the group that represents you the best.

- Researcher: Educational Sciences
- Researcher: Computer Sciences
- Researcher: Educational Technology
- Researcher: Psychology
- Researcher: Other \_\_\_\_\_
- Educator: Formal Education
- Educator: Informal Education
- Educator: Workplace Learning
- Educator: Other \_\_\_\_\_
- Business: Research & Development
- Business: Salesperson
- Business: Other \_\_\_\_\_
- Policy-maker
- Other \_\_\_\_\_

If you like to add **up to three** additional groups.

- Researcher: Educational Sciences
- Researcher: Computer Sciences
- Researcher: Educational Technology
- Researcher: Psychology
- Researcher: Other \_\_\_\_\_
- Educator: Formal Education
- Educator: Informal Education
- Educator: Workplace Learning
- Educator: Other \_\_\_\_\_
- Business: Research & Development
- Business: Salesperson
- Business: Other \_\_\_\_\_
- Policy-maker
- Other \_\_\_\_\_

[PAGE 3]

## **Part II: Areas of Tension**

The second part of this questionnaire refers to five Areas of Tension within the field of TEL that were identified in the previous Delphi rounds.

You will be asked to state your personal opinion on these Areas of Tension:

- Data tracking for personalized learning versus Data privacy
- Digital divide despite technology spread
- Ubiquitous learning opportunities versus Focused and critical processing of information
- Approved practices versus Continuous innovation in the classroom
- Individual learning paths versus Standardized learning paths

Please read the positions A and B of the Areas of Tension carefully; the information provided in the text is crucial for answering the following questions

[PAGE 4]

## **PART II: Area of Tension (1 of 5)**

### **Data tracking for personalized learning versus Data privacy**

#### **Position A:**

**Keeping track of a learner's data in order to enable the personalization of learning environments is a key issue in TEL.** With the help of detailed and accurate records, personalized instruction can facilitate learning by adapting to the learner's individual learning history, affective characteristics, learning styles, or interests. Future technology-enhanced learning environments will therefore collect and store large amounts of user data, and will communicate these data with other tools in order to provide the best possible support across learning contexts. Learners will no longer remain anonymous to the tools and programs they use for learning. The advantages of such transparency will by far outweigh its disadvantages, thus learners will provide information in order to get the best out of their learning tools.

#### **Position B:**

Data privacy will be a major concern in the future of TEL. Personalized learning support in particular, where data storage and exchange it requires, can endanger the learners' data privacy, that is, the learner's control over the storage, use, and dissemination of his or her personal data. **Data privacy is an important goal because it prevents misuse of personal data, such as a person's learning history.** Such data could, for example, be misused for unfair evaluations of job candidates, or for taking control of people's learning trajectories in a patronizing way. For instance, without data privacy inaccurate information, once entered and distributed, could have a negative impact on a person's life. The development of data security concepts as well as the teaching of data literacy skills that ensure maximal control over one's personal data will therefore be key focus of the future of TEL.

**How strong do you think the tension between Position A and Position B is today?**

Not strong  Very strong

**How strongly do you identify with Position A?**

Not at all  Very much

**How strongly do you identify with Position B?**

Not at all  Very much

**How strong do you think the tension between Position A and Position B will be in 10 years?**

Not strong  Very strong

**In the next 10 years: How much impact will this Area of Tension have on**

|                    | no impact   | large impact |
|--------------------|---|--------------|
| society in general | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| educational sector | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| TEL research       | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| your field of work | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |

**Any comments, questions, remarks, or ideas concerning this Area of Tension in relation to your field of work.**

**In the next 10 years: How much influence will the following actors have on the developments within this Area of Tension?**

|                            | no influence  | large influence |
|----------------------------|---|-----------------|
| researchers                | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| policy makers/politicians  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| practitioners in education | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| society                    | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| learners/end-users         | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |

**General comments:**

[PAGE 5]

**PART II: Area of Tension (2 of 5)**

**Digital divide despite technology spread**

**Position A:**

Technological developments often sustain existing social inequities. For instance, developing countries have low levels of technological infrastructure and (computer) literacy as compared to industrial countries. Additionally, large amounts of information are provided in merely a few dominant languages like English, and thus cannot be accessed by everybody. Consequently, research has provided evidence that people who are already privileged in the usage of technology often benefit the most from new ICT developments. **Hence, there is a real danger that future TEL solutions, too, will sustain or even enlarge the already existing “digital divide”**

between people with and without access to educational and informational resources.

**Position B:**

There are many promising initiatives and projects aiming at improving the technical infrastructure (e.g. one laptop per child) and creating the social preconditions (e.g. through teacher training) for offering access to educational and informational resources to the poor and disadvantaged. **Technology-enhanced learning solutions that capitalize on the development and increasing spread of smaller, cheaper, and easier to use technological tools will empower disadvantaged people and thus help to reduce the digital divide.** For example, TEL solutions will help to provide easy access to information and education in developing countries. Thus, due to technological advances and the initiatives already taken by researchers, politicians, and other stakeholders, there is a realistic chance that we will be able to overcome the digital divide in the future.

**How strong do you think the tension between Position A and Position B is today?**

Not strong  Very strong

**How strongly do you identify with Position A?**

Not at all  Very much

**How strongly do you identify with Position B?**

Not at all  Very much

**How strong do you think the tension between Position A and Position B will be in 10 years?**

Not strong  Very strong

**In the next 10 years: How much impact will this Area of Tension have on**

|                    | no impact   | large impact  |
|--------------------|---|---|
| society in general | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| educational sector | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| TEL research       | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| your field of work | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |

**Any comments, questions, remarks, or ideas concerning this Area of Tension in relation to your field of work.**

**In the next 10 years: How much influence will the following actors have on the developments within this Area of Tension?**

|                            | no influence  | large influence   |
|----------------------------|---|---|
| researchers                | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| policy Makers/politicians  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| practitioners in education | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| society                    | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| learners/end-users         | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |

**General comments:**

[PAGE 6]

**PART II: Area of Tension (3 of 5)**

**Ubiquitous learning opportunities  
versus  
Focused and critical processing of information**

**Position A:**

**Technology-enhanced learning capitalizes on the possibilities offered by modern mobile and portable devices, which enable ubiquitous information access and thus ubiquitous learning opportunities.** Today's students are "digital natives" who grew up with technology and use it naturally. They already have developed useful strategies and skills to find and handle the information they need. Search engines such as Google offer increasingly accurate search results and thus help to filter the enormous amount of available information. In addition, context-aware devices enable contextualized learning experiences by adapting the information they provide to the situation or context of the person. Technology-enhanced learning should build on these societal and technological advances by making the world's information available and accessible to each learner at any time and any place.

**Position B:**

**Ubiquitous access to information and communication resources can lead to distractions from the learning process.** For instance, modern students often divide their attention between many tools at the same time, such as simultaneously experimenting in a virtual lab, speak to a learning partner on the phone, and search for relevant information on the Web and in textbooks. This multi-tasking distracts students from the focused and elaborated processing of information. Further, the vast amount of information easily leads to a fast and superficial processing of the learning content. This enhances biases like the "confirmation bias" (i.e. learners tend to focus on information that confirms their own hypotheses or attitudes, and to disregard disconfirming information). Technology-enhanced learning should therefore focus on training essential skills for identifying and focussing on relevant aspects, searching information and testing hypotheses, and for elaborating on learning content. Learning activities and settings should aim for an attentive, conscious, and holistic learning experience, and for ensuring the acquisition of both factual and metacognitive knowledge.

**How strong do you think the tension between Position A and Position B is today?**

Not strong  Very strong

**How strongly do you identify with Position A?**

Not at all  Very much

**How strongly do you identify with Position B?**

Not at all  Very much

**How strong do you think the tension between Position A and Position B will be in 10 years?**

Not strong  Very strong

**In the next 10 years:** How much impact will this Area of Tension have on

|                    | no impact  | large impact |
|--------------------|--|--------------|
| society in general | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| educational sector | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| TEL research       | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| your field of work | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |

**Any comments, questions, remarks, or ideas concerning this Area of Tension in relation to your field of work.**

**In the next 10 years:** How much influence will the following actors have on the developments within this Area of Tension?

|                            | no influence   | large influence |
|----------------------------|--|-----------------|
| researchers                | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| policy Makers/politicians  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| practitioners in education | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| society                    | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| learners/end-users         | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |

**General comments:**

[PAGE 7]

## **PART II: Area of Tension (4 of 5)**

### **Approved practices versus Continuous innovation in the classroom**

#### **Position A:**

Research on technology-enhanced learning should, whenever possible, be grounded in well-established educational theories, and in practices that have been proven beneficial for learning. **The ultimate goal of TEL in the classroom should be to create and support reliable, well established and highly successful school practices.** New technologies should only be adapted into real-world classrooms when their usefulness for learning has been proven. Usage of technology as an end in itself should be prevented. For instance, the unreflecting use of new learning technologies bares the risk that learners will engage in a shallow learning process, and that ineffective educational practices are simply carried on with new technological tools. Thus, TEL research should aim to clarify in which ways a new technology can enhance didactic concepts, and assure that only those TEL solutions that have been proven to be effective for learning are applied in the classroom.

#### **Position B:**

The adoption of new technological tools in the classroom often sparks the employment of new and innovative educational methods and concepts. For instance, mobile devices facilitate new forms of contextualized learning, computer simulations enable new forms of inquiry learning, and communication tools support new forms of collaborative learning. **Therefore, new technological tools and TEL**

**solutions should be employed in real-world classrooms as early as possible, enabling a constant evolution and shaping of learning settings and educational practices.** Furthermore, the adoption of new technologies in the classroom also ensures that learners become acquainted with innovative developments and thus improve their computer literacy. It is therefore important that teachers are familiar with new technological developments and quickly integrate them into their classrooms. In doing so, they will continuously take their educational practices to the next level.

**How strong do you think the tension between Position A and Position B is today?**

Not strong  Very strong

**How strongly do you identify with Position A?**

Not at all  Very much

**How strongly do you identify with Position B?**

Not at all  Very much

**How strong do you think the tension between Position A and Position B will be in 10 years?**

Not strong  Very strong

**In the next 10 years:** How much impact will this Area of Tension have on

|                    | no impact   | large impact |
|--------------------|---|--------------|
| society in general | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| educational sector | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| TEL research       | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| your field of work | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |

**Any comments, questions, remarks, or ideas concerning this Area of Tension in relation to your field of work.**

**In the next 10 years:** How much influence will the following actors have on the developments within this Area of Tension?

|                            | no influence  | large influence |
|----------------------------|---|-----------------|
| researchers                | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| policy Makers/politicians  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| practitioners in education | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| society                    | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |
| learners/end-users         | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |                 |

**General comments:**

[PAGE 8]

**PART II: Area of Tension (5 of 5)**

**Individual learning paths  
versus  
Standardized learning paths**

**Position A:**

The development of new technological tools and the changes of the educational landscape enable people to create their own learning paths regarding content, interests, needs, and skills. The result is **an infinite number of possible individual learning profiles that guarantee a more comprehensive and transdisciplinary evolution of our knowledge**. Furthermore, individualised learning paths can facilitate learning as students are most motivated to deal with subjects they are interested in and feel responsible for. Individualised learning paths can thus increase learning progress and success. Consequently, we should allow learners plenty of room for their individual ideas about what and how to learn and provide them with technological tools and meta-cognitive skills that make this individualisation possible.

**Position B:**

Although individual learning paths provide new opportunities for learning and education, we run the risk of losing common standards and educational norms. **Standardization is essential for proper assessment, accreditation, and better comparison** of degrees, as well as comparison of content and skills that have been learnt. Even more important, learners will often lack the skills and competencies to create a coherent sequence of learning events in their area of interest. As novices in that field they will have difficulties to identify meaningful learning goals and objectives. **Standardized learning paths can provide academic guidance and faster access to the essential contents of a domain**. Finally, standardization of educational content supports communication and collaboration by ensuring a **common ground of mutually shared knowledge within a society**. Technology-enhanced education should therefore focus on offering its learners standardized learning trajectories that have been professionally created and evaluated.

**How strong do you think the tension between Position A and Position B is today?**

Not strong  Very strong

**How strongly do you identify with Position A?**

Not at all  Very much

**How strongly do you identify with Position B?**

Not at all  Very much

**How strong do you think the tension between Position A and Position B will be in 10 years?**

Not strong  Very strong

**In the next 10 years:** How much impact will this Area of Tension have on

|                    | no impact  | large impact |
|--------------------|--|--------------|
| society in general | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| educational sector | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| TEL research       | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |
| your field of work | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |              |

**Any comments, questions, remarks, or ideas concerning this Area of Tension in relation to your field of work.**

**In the next 10 years:** How much influence will the following actors have on the developments within this Area of Tension?

|                            | no influence   | large influence  |
|----------------------------|--|--|
| researchers                | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |  |
| policy Makers/politicians  |  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| practitioners in education |  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| society                    |  | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |
| learners/end-users         | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> |  |

**General comments:**

[PAGE 9]

### **Part III: Core Research Areas**

In the final part of this survey, you are asked to prioritize 11 Core Research Areas according to their importance for future TEL research. In addition, we ask you to sketch out a possible research project for one of these Core Research Areas. The Core Research Areas derive from the experts' input in the previous Delphi rounds. You can find a short description of each Core Research Area by clicking on the Core Research Area of interest.

Computer-Supported Collaborative Learning

Connection between Formal and Informal Learning

Contextualized Learning

Emotional and Motivational Aspects of Technology-Enhanced Learning

Improve Practices of Formal Education

Informal Learning

Interoperability

Personalized Learning

Reducing the Digital Divide

Ubiquitous & Mobile Technology and Learning

Workplace Learning

**Please prioritize the presented Core Research Areas according to your assessment of their importance for TEL research in the next 10 years.**

You can simply use the drag and drop functionality to order the Core Research Area in the box presented on the right.

- Computer-Supported Collaborative Learning
- Reducing the Digital Divide
- Personalization of Learning
- Contextualized Learning
- Workplace Learning
- Ubiquitous & Mobile Technology and Learning
- Emotional and motivational aspects of Technology-Enhanced Learning
- Informal Learning
- Improve Practices of Formal Education
- Connection between Formal and Informal Learning
- Interoperability

**General comments:**

[PAGE 10]

**Part III: Core Research Areas**

**Imagine that research funding is made available to carry out research projects in TEL. You can apply for a research project in one of the presented research areas.**

Please select one of the presented Core Research Areas in which you would apply for a research project.

▼

**Please sketch out the project you would like to investigate until 2020, and describe how it addresses the Core Research Area selected above.**

Title:

Research questions and short description:

Collaborating partners/institutions:

Justification (i.e. societal, technological, and scientific relevance):

**General comments:**

[PAGE 11]

**General Feedback**

Please feel free to give feedback to the survey in general:



**You have completed the survey. You may still move back and edit answers.  
By clicking on the "next" button on this page you can submit your answers.  
You won't be able to move back and change your answers after that.**

[PAGE 12]

**Thank you for participating in the STELLAR Delphi study!**

**Best regards,  
The Stellar Delphi Team**

## B 4<sup>th</sup> STELLAR Delphi Round – Global Panel of Experts

- Abdallah Y. Al-Zoubi
- Abdel-Badeeh M. Salem
- Abelardo Pardo
- Adam C. Angelis
- Adrian Kapias
- Adrian Oldknow
- Agathe Merceron
- Agnes Kukulska-Hulme
- Agnieszka Chrzęszcz
- Aikyna Finch
- Aisha Walker
- Alain Mille
- Alain Senteni
- Alejandra Martínez
- Alexander Renkl
- Alison Clark-Wilson
- Alison Egan
- Alke Martens
- Allen Partridge
- Allison Littlejohn
- Allison Rossett
- Ana Dias
- Ana Arruarte
- Ana Paiva
- Anders Kluge
- Andras Szucs
- André Richier
- Andrea Parola
- Andrea Forbes
- Andrea Valente
- Andreas Lingnau
- Andrew King
- Andrew Ravenscroft
- Andy Black
- Angelique Dimitracopoulou
- Angie ReidGriffin
- Anne Forster
- Anne Manuel
- Annette Lopez de Mendez
- Anniken Furberg
- Antoinette Bruciati
- António Santos
- Antonio De Girolamo
- Antonio Fini
- Antonio Padilla-Meléendez
- Antti Auer
- Ard Lazonder
- Ari Korhonen
- Arif Altun
- Armin Weinberger
- Arnis Voitkans
- Ashok Goel
- Asrun Matthiasdottir
- Astrid Guiffart
- Avril Loveless
- Ayleen Driver
- Baohui Zhang
- Barbara Ann M. Messina
- Barbara Di Eugenio
- Barbara Kump
- Barbara Thönssen
- Barry Fishman
- Ben Chang
- Benedict du Boulay
- Bernadette Charlier
- Beverly Park Woolf
- Bob Fox
- Bob Harrison
- Bodo Urban
- Boriss Misnevs
- Brandon Muramatsu
- Brian Holmes
- Brigitte Hänggi
- Bryan Berry
- Carlo Giovannella
- Carlo Perrotta
- Carlos San José
- Carmel McNaught
- Caroline Bardini
- Caroline M. Crawford
- Carsten Ullrich
- Catherine Beavis
- Catherine C. Schifter
- Chan Kan Kan
- Charalampos Karagiannidis
- Chareen Snelson
- Charles M Patton
- Chee-Kit Looi
- Chen Wenli
- Chengjiu Yin
- Chien-Sing Lee
- Chris Dennett
- Chris Sangwin
- Christian Buty
- Christian Depover
- Christian Kohls

- Christian Spannagel
- Christina Preston
- Christina Solomonidou
- Christine Bauer
- Christoph Igel
- Christopher Brook
- Christopher Hoadley
- Cindy Hmelo-Silver
- Cindy Kerawalla
- Clara Coutinho
- Clark Quinn
- Claus Rainer Michalek
- Craig Montgomerie
- Curby Alexander
- Cynthia Choi
- Dan Chen
- Dan Medicoff
- Dan Sutch
- Daniel K. Schneider
- Daniel Livingstone
- Daniel Pascual
- Daniel Schwartz
- Daniel Weiler
- Daniela Giordano
- Danielle McNamara
- Dave Pratt
- David Gibson
- David Jonassen
- David Kay
- David Kernohan
- David Metcalf
- David Parsons
- David Pugalee
- David Slykhuis
- David Williamson Shaffer
- Davide Parmigiani
- Davina Pruitt-Mentle
- Davinia Hernández-Leo
- Debra Hiom
- Demetrios G Sampson
- Derick Leony
- Diana Perez-Marin
- Diane Igoche
- Dina Rosen
- Diego Zapata
- Dimitrios A. Georgiou
- Dina Vyortkina
- Don Sheridan
- Douglas Butler
- Ian Reid
- Kirsten Cater
- Edward D Laughbaum
- Elad Moskovitz
- Elen Jan
- Elena Moschini
- Elena Sassi
- Elena Verdu
- Eleni Kyza
- Ellen Wagner
- Ellen Yi-Luen Do
- Elvira Popescu
- Emma Place
- Emmanuel Jamin
- Emmanuel Zammit
- Eric Bruillard
- Erica de Vries
- Eshaa M. Alkhalifa
- Eugenio Marchiori
- Evelyn Ting
- Fabrizio Cardinali
- Fabrizio Giorgini
- Felix Mödritscher
- France Henri
- Francis Brouns
- Frans Van Assche
- Fred Paas
- Fuchang Liu
- Fu-Kwun Hwang
- Fu-Yun Yu
- Gabi Reinmann
- Gaëlle Molinari
- Galia Angelova
- Garlatti Serge
- Gautam Biswas
- Gayle V. Davidson-Shivers
- Genaro Rebolledo-Mendez
- Gerhard Fischer
- Gianpaolo Barozzi
- Giasemi Vavoula
- Graham Attwell
- Gudrun Bachmann
- Guido Roessling
- Günter Wageneder
- Gwo-Jen Hwang
- H. Chad Lane
- Haniph Latchman
- Hans-Christian Schmitz
- Harrison Yang
- Heather Price
- Heeok Heo
- Heide Lukosch
- Helen Tracy
- Helmut M. Niegemann
- Henk Sligte

- Henry Been-Lirn Duh
- Hermann Maurer
- Hilary Wilder
- Hiroaki Ogata
- Holzäpfel
- Huei-Tse Hou
- Iain Doherty
- Ian Galloway
- Ian Gibson
- Ido Roll
- Imre Knausz
- Ingrid A. R. Grønsdal
- Ingvill Rasmussen
- Inmaculada Arnedillo-Sánchez
- Ioannis Kazanidis
- Irene Chen
- Jacques Lonchamp
- Jaetaek Yoo
- James A. Telese
- Jan Reichelt
- Jana M Willis
- Jane Williams
- Janet Ainley
- Jarkko Suhonen
- Jarmila Novotna
- Jasper Tredgold
- Javier Melero
- Javier Torrente
- Jelena Jovanovic
- Jennifer Sparrow
- Jenny Orton
- Jeremy Roschelle
- Jerry Leeson
- Jeton McClinton
- Jim Devine
- Jim Slotta
- Joachim Funke
- Jocelyn Manderveld
- Jocelyn Wishart
- Jochen Robes
- Joel Donna
- Joerg M. Haake
- Johanna Hulkko
- Johannes Magenheim
- Johannes Moskaliuk
- John Alonso
- John Charlton
- John Cook
- John Davis
- John Sweeder
- John Traxler
- Jon Dron
- Joseph David Cullen
- Josu Aramberri
- Juan M. Dodero
- Juana M Sancho
- Judi Harris
- Judith Schoonenboom
- Judy Kay
- Julie Mueller
- Ju-Ling Shih
- Junko Yamamoto
- Jyrki Pulkkinen
- Karl Steffens
- Katharina Scheiter
- Kathryn Shafer
- Katie Goeman
- Kazys Baniulis
- Keith Jones
- Kenneth R. Koedinger
- Keri Facer
- Keryn Pratt
- Kevin Hayes
- Kevin Thomas
- Kirk Vandersall
- Kirsten Berthold
- Kirsti Ala-Mutka
- Klaus Bredl
- Kong Siu Cheung
- Krassen Stefanov
- Kristine Lund
- Kurt Hoffmann
- Kurt Squire
- Kurt VanLehn
- Kyparisia Papanikolaou
- Lam-for Kwok
- Lars Svensson
- Leanne Cameron
- Leo Højsholt-Poulsen
- Leo Plugge
- Leonie Ramondt
- Lesly Huxley
- Linda Easley
- Lisa Davis Cark
- Lisa Gjedde
- Lisa Grable
- Lisa Petrides
- Liz Falconer
- Lluïsa Nuñez
- Lorenzo Cantoni
- Lori Lockyer
- Lori Shyba
- Lorna Uden
- Luc Trouche

- Lucia Pannese
- Luigi Guerra
- Luis Anido
- Luís Capucha
- Luis María Cascales García
- Lung-Hsiang Wong
- Lydia Lau
- Lyn Pemberton
- Lyndsay Grant
- M. Beatrice Ligorio
- Maggie McPherson
- Maggie Veres
- Maiga Chang
- Mak D Gross
- Malcolm Hughes
- Malcolm Ryan
- Mandy Schiefner
- Manolis Mavrikis
- Manuel Frutos-Perez
- Manuel Ortega
- Marc Krüger
- Marco Biocca
- Marco Kalz
- Maren Scheffel
- Margit Timakov
- Margus Pedaste
- Maria Bielikova
- Maria Earman Stetter
- Maria Grazia Ierardi
- María Jesús Verdú
- Maria Lucia Giovannini
- Marian Babiak
- Marie-Hélène Abel
- Marina Gall
- Mario Rotta
- Mark A.M. Kramer
- Mark Brown
- Mark Rodriguez
- Mark van 't Hooft
- Markus Herkersdorf
- Markus Kemmerling
- Mart Laanpere
- Marta Turcsanyi-Szabo
- Martin Ebner
- Martin Llamas-Nistal
- Martin VALCKE
- Martin Wolpers
- Marvin Peyton
- Mary Ulicsak
- Massimo de Cristofaro
- Mathy Vanbuel
- Matija Lokar
- Matthew Allen
- Matthew Boggan
- Matthias Holzner
- Maya Satratzemi
- Meg O'Reilly
- Mehmet Fatih Döğ̈er
- Melanie Shoffner
- Meng-Jung Tsai
- Merryellen Towey Schulz
- Metka Zorič-Venuti
- Michael Auer
- Michael Baker
- Michael K. Barbour
- Michael Kerres
- Michael Kickmeier-Rust
- Michael Land
- Michael Toepel
- Michael Verhaart
- Michel Desmarais
- Michele Notari
- Miguel Gea
- Mike Keppell
- Mike Searson
- Min Kyu Kim
- Ming-Puu Chen
- Mircea Ilie Mihaiu
- Mireille Betrancourt
- Mohamed Ally
- Monica Landoni
- Monique Fuchs
- Monique Grandbastien
- Moushir M. El-Bishouty
- Muhammad Betz
- Naama Axelrod Tayer
- Naomi Norman
- Nathalie Sinclair
- Nathalie Van De Wiele
- Neil Heffernan
- Nelson Baloian
- Nelson Sousa
- Ng Khar Thoe
- Nian-Shing Chen
- Nick Breeze
- Niels Pinkwart
- Nikos Karacapilidis
- Noboru Matsuda
- Norbert Pachler
- Norman Garrett
- Nuno M. Guimarães
- Nuno Otero
- Ornella Robutti
- Pablo Moreno Ger

- Päivi Häkkinen
- Palmyre Pierroux
- Pamela Whitehouse
- Paolo Maria Ferri
- Pat Triggs
- Patricia Marzin
- Patricio Herbst
- Patrick Blumschein
- Patrick Jermann
- Paul Bailey
- Paul Brna
- Paul Coyne
- Paul Desmarais
- Paul Drijvers
- Paul Hollins
- Paul Kirschner
- Paul Lefrere
- Paula Hodgson
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- Peraqya Daniel
- Peter Albion
- Peter Gerjets
- Peter Reimann
- Peter Sloep
- Petra Grell
- Petra Oberhuemer
- Phil Hall
- Philip Edmonds
- Philip Reimer
- Philippe Fournier-Viger
- Piet Kommers
- Priscilla Norton
- Qing Tan
- Qun Jin
- Rafael Morales
- Raffier Moeller
- Raj Boora
- Ranguelov
- Regina Royer
- Reinhard Oppermann
- Reinhold Hawle
- Rhonda Christensen
- Ricardo Conejo
- Riccardo Mazza
- Richard Catrambone
- Richard Cox
- Richards Griff
- Richard Huntrods
- Richard Joiner
- Richard Noss
- Richard Sandford
- Rita Kuo
- Rob Koper
- Robert Atkinson
- Robert de Hoog
- Robert N Ronau
- Robyn MacKillop
- Robyn Pierce
- Roger Blamire
- Rolf Reinhardt
- Ron Oliver
- Ronald Sarnier
- Rosa Maria Vicari
- Rosalba Saija
- Rose Luckin
- Rosella Gennari
- Roy Pea
- Russell Francis
- Russell Johnson
- Ruth Wood
- Ryan Baker
- Ryan Flynn
- Ryuichi Matsuba
- Samra Mujacic
- Santi Scimeca
- Sara Hennessy
- Sara McNeil
- Sara Zimmerman
- Sarah Cornelius
- Sarah Knight
- Sarah Porter
- Sari Koski-Kotiranta
- Savilla Banister
- Sean Lancaster
- Seb Schmoller
- Sebastián Dormido
- Seth Giddings
- Shahron Williams van Rooij
- Sheila Crew
- Shinichi Konomi
- Silvia Kantcheva
- Simon Yip
- Simos Retalis
- Slavi Stoyanov
- Srinivasan Ramani
- Sriram Subramanian
- Stavros Demetriadis
- Stefaan ternier
- Stefania Bocconi
- Stefanie Panke
- Sten Ludvigsen
- Stephan Schwan
- Stephan Weibelzahl
- Stephanie Burton

- Steve Leung
- Steve Ritter
- Steve Whitaker
- Sue Bennett
- Sue Cranmer
- Sujing Zhang
- Susan Powers
- Swapna Kumar
- Tamara van Gog
- Tammy Schellens
- Tel Amiel
- Teresa Cerratto Pargman
- Teresa Franklin
- Teresa Holocher
- Thomas C. Reeves
- Thomas de Lange
- Thomas Herrmann
- Thomas M Connolly
- Thomas Ryberg
- Tim Jay
- Tim Pelton
- Tim Rudd
- Tim Schlotfeldt
- Tim Tarrant
- Tina Seufert
- Tiong-Thye Goh
- Todor Krastevich
- Tomas Dulik
- Ton de Jong
- Torsten Reiners
- Toshio Okamoto
- Uwe Riss
- Uwe Seidel
- Uwe Wilkesmann
- Vassilios Dagdilelis
- Veijo Meisalo
- Victoria Brown
- Viktoria Pammer
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- William J. Hunter
- Wim Westera
- Wolf Hilzensauer
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- Xavier Ochoa
- Yasemin Gulbahar
- Yavuz Akpınar
- Yi Li
- Yuri Matteman
- Yves Punie
- Zacharias Zacharia
- Zimmermann
- Zinayida Petrushyna