Intermediate report on the Delphi study

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D1.3A

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Findings from the 2nd and 3rd STELLAR Delphi Rounds: Areas of Tension and Core Research Areas

Edited by
Hans Spada, Christine Plesch, and Celia Kaendler

SEVENTH FRAMEWORK PROGRAMME

STELLAR

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Areas of Tension and Core Research Areas

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Executive Summary

We provide this intermediate report on the STELLAR Delphi study for closing the gap between the first deliverable on the Delphi study D1.3 (Spada et al., 2010) which was published in July 2010 and the second and final deliverable D1.6 which is planned for January 2012. The first deliverable D1.3 provided an overview of the planned five-round STELLAR Delphi study and presented preliminary results of the first Delphi round. Since the publication of D1.3, we have completed two more Delphi rounds. In this intermediate report, we present the results of these two rounds and provide an outlook on the steps that are planned for the future. The final deliverable D1.6 will concentrate on integrating the findings across all five STELLAR Delphi rounds.

The STELLAR Delphi study aims at identifying future themes for technology-enhanced learning (TEL) research and explores opinions and visions held by European and global TEL stakeholders and researchers. In line with one of the main goals of the STELLAR network, we implement the Delphi study to create a catalogue of recommendations for future TEL research on the European level and beyond.

The Delphi method is a forecasting technique and encompasses a series of questionnaire rounds for identifying and exploring experts' opinions and visions on future trends in their domain of expertise. The STELLAR Delphi study is composed of five rounds; three internal rounds (1st, 3rd, and 5th STELLAR Delphi round) that are conducted within the STELLAR network and two large, global survey rounds (2nd and 4th STELLAR Delphi round) among TEL experts from outside the STELLAR network. The external survey rounds involve a large number of global TEL stakeholders and researchers.

Two STELLAR-internal rounds (1st and 3rd STELLAR Delphi round) and the first global survey (2nd STELLAR Delphi round) have been completed so far. In the 1st STELLAR Delphi round (see D1.3), we employed a qualitative questionnaire format with open-ended questions. The textual input of the participants was coded and resulted in category systems with topics and subtopics. The 1st STELLAR Delphi round was completed in 2009 and provided the foundation for the planning and implementation of the 2nd STELLAR Delphi round – the first of two global surveys.

In the questionnaire design process of the 2nd STELLAR Delphi round, we utilized the results of the preceding qualitative Delphi round to develop standardized, scalable items. The first part of this survey encompassed rating items on Future Trends in TEL and TEL research; the experts evaluated a) the importance of future societal demands/challenges that TEL research should respond to, b) the impact of future technological developments on TEL research,

and c) the importance of future TEL research themes. In the second part of the survey, statements about visions concerning TEL in general and TEL research in particular were evaluated for their desirability and their likelihood of becoming reality by 2025. The global panel of experts consisted of 230 TEL experts; their professional background was mainly in research, but also in development of software/technology, policy making, business, and practice/formal education.

The 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 first goal for the consecutive Delphi round was 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. The experts' ratings of the statements about visions for TEL revealed conflicting views on certain aspects of TEL and TEL research and led to the second goal of the consecutive Delphi round - the identification of *Areas of Tension*. An Area of Tension presents two opposing views on a certain future development in TEL. These two positions within each Area of Tension reflect underlying issues that were identified in the experts' ratings, in their additional comments regarding these statements, and in the content of additionally generated statements. In short, the results and conclusions of the 2nd Delphi round provided the foundation for the 3rd Delphi round in which the final Areas of Tension and Core Research Areas were developed. The first part of this report presents the results and conclusions of the first global survey round (2nd STELLAR Delphi round).

The second part of this report is focused on the 3rd STELLAR Delphi round (STELLAR-internal), that is, the development of Areas of Tension and Core Research Areas based on the results of the 2nd STELLAR Delphi round. The 3rd Delphi round was carried out in the form of two workshops in Freiburg, Germany, in July and August 2010.

Together with 13 researchers of the STELLAR network, we worked on the development and refinement of five *Areas of Tension* for TEL:

- The 1st 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 2nd 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 3rd Area of Tension contrasts the advantages of technology-enhanced learning anywhere at any time with the need for focused and critical processing of information.

- In the 4th Area of Tension the reliance on approved school practices is opposed to the immediate adoption of innovative technology in the classroom.
- The 5th 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.

Furthermore, the input of the workshop participants led to the final description of 11 Core Research Areas for TEL:

- computer-supported collaborative learning,
- ubiquitous & mobile technology/learning,
- interoperability,
- emotional and motivational aspects of learning,
- reducing the digital divide,
- improve practices of formal education,
- informal learning,
- connection between formal and informal learning,
- workplace learning,
- contextualized learning,
- personalization of learning.

We are currently conducting the 4th STELLAR Delphi round – the final global survey. The survey that was distributed in January 2011 asks experts to assess the relevance of these five Areas of Tension for future research in TEL and to prioritize the 11 Core Research Areas. In fall 2011, we will organize workshops in which STELLAR experts and representatives of TEL-stakeholders will discuss the results of the preceding Delphi rounds. These workshops constitute the beginning of the 5th Delphi round – the final STELLAR-internal round. It will serve to integrate the findings across all rounds and to disseminate them.

Ultimately, the experts' input across all Delphi rounds 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.

1 Introduction - STELLAR Delphi Study

In STELLAR, we implement the Delphi technique to involve a global panel of researchers and stakeholders in the iterative process of co-constructing a catalogue of recommendations for future research in technology-enhanced learning (TEL).

1.1 Plan of Action

In order to achieve this goal, a 5-round Delphi process has been planned (see Figure 1). It consists of two large global survey-rounds among TEL experts from outside the STELLAR research network (2^{nd} and 4^{th} Delphi round) and three internal rounds that are conducted within the STELLAR network (1^{st}, 3^{rd}, and 5^{th} Delphi round). The internal rounds serve to prepare, analyze, and discuss the external, global surveys and to integrate and distribute the results.

Three rounds have been completed so far. The results of the 1^{st} Delphi round, and the planning, the panel of experts, and the questionnaire of the 2^{nd} Delphi round have been described in the previous deliverable on the STELLAR Delphi study (D1.3, Spada et al., 2010)

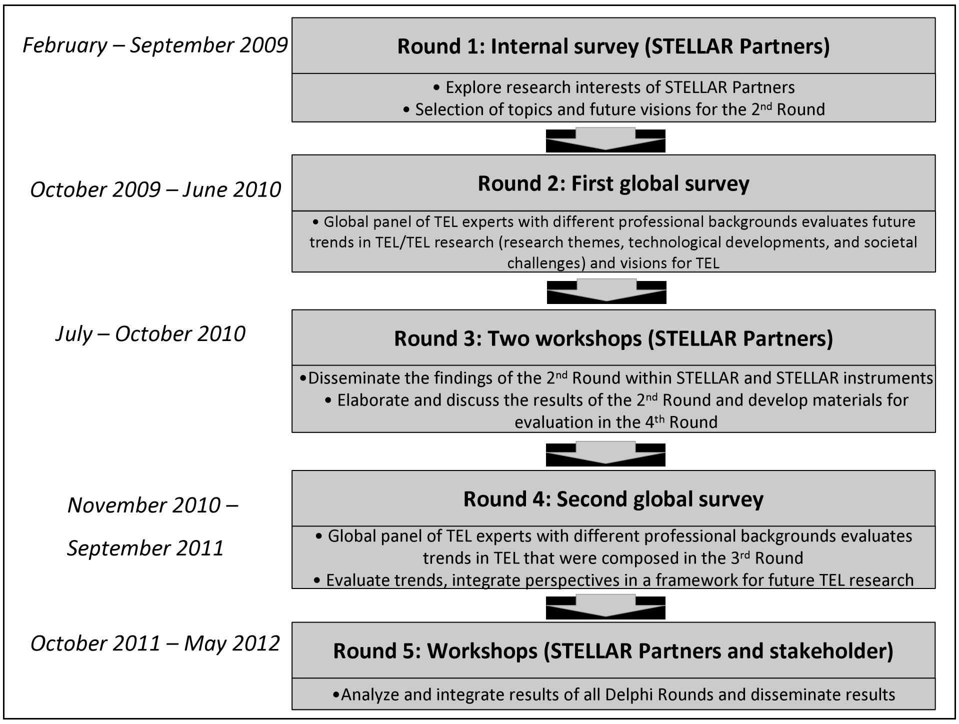

Figure 1. Agenda of the STELLAR Delphi study

This annex presents the results of the 2^{nd} Delphi round, the first global survey, and the 3^{rd} Delphi round - two workshops with STELLAR members.

1.2 Overview of STELLAR Delphi Activities from April 2010 until January 2011

Since the STELLAR review meeting in Luxembourg in April 2010, we analyzed the results of the 2nd STELLAR Delphi study, completed the 3rd Delphi round in the form of two workshops held in Freiburg in summer 2010, and prepared the 4th Delphi round (see Figure 2).

The 2nd Delphi round took place from February to March 2010 followed by the data analysis from April to July. The data analysis and the corresponding results were not presented in D1.3 which was published in July 2010 and are therefore reported in the following chapter. For the 3rd Delphi round, a STELLAR-internal round, we implemented two face-to-face workshops with STELLAR members in Freiburg. Both of these workshops incorporated sessions dedicated to WP1 integration and sessions dedicated to the dissemination and further elaboration of the Delphi results. The preparation, planning, and implementation of the Delphi-sessions in these workshops are described in chapter 3. The preparation of the questionnaire and the recruiting for the 4th Delphi round started in October 2010. In the survey of the 4th STELLAR Delphi round that has started in January 2011, we ask a global panel of experts to evaluate and elaborate the findings and results of the 2nd and 3rd Delphi round.

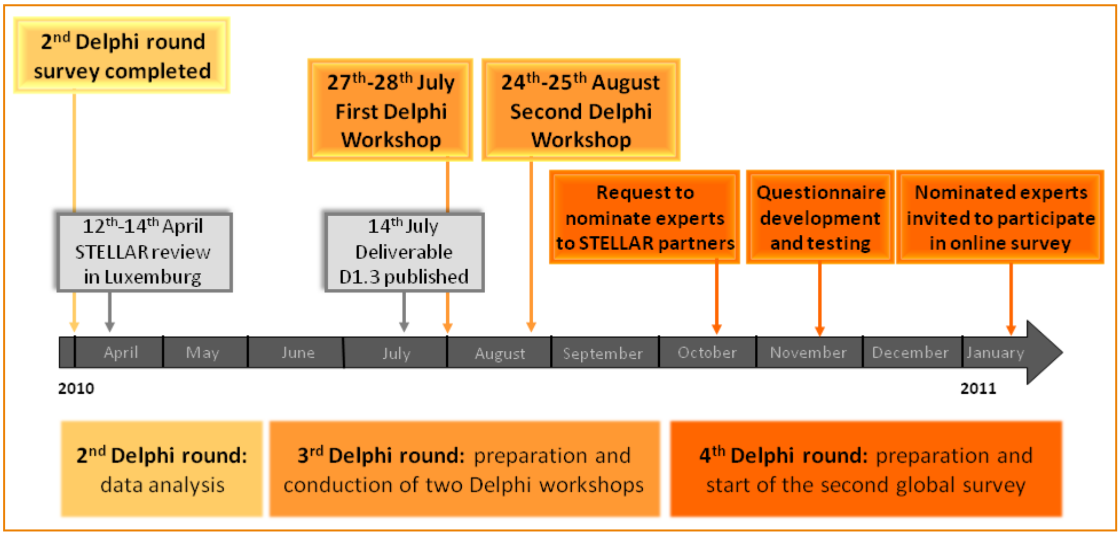

Figure 2. Overview of STELLAR Delphi study from April until January 2011.

For the purpose of disseminating the preliminary results of the STELLAR Delphi study, we produced a research briefing presenting the results of the 2nd and 3rd STELLAR Delphi round in an integrative format (see Appendix C). The briefing was designed with the help of members of the STELLAR teams at University of Bristol and Open University. The Delphi briefing will be printed as a leaflet and will be handed out at research conferences and stakeholder meetings. It was also published as part of deliverable D1.4.

The results of the 3rd Delphi round provided the input for the first virtual Meeting of the Minds (vMoM) in November 2010. We prepared the materials that were sent out to the members of the vMoM. The vMoM was organized in cooperation with the STELLAR teams at Katholieke Universiteit Leuven and Ludwig-Maximilians University Munich. Erik Duval moderated the vMoM and Hans Spada contributed to the discussions as the leader of the Freiburg Delphi team.

Additionally, we disseminated the results of the STELLAR Delphi study at the International Conference of Computers in Education in November 2011 in Malaysia (Plesch et al., 2010). The results of the 2nd and 3rd Delphi round were presented and discussed with experts from the Asian-Pacific continents as well as with American and European experts. Additionally, we submitted a paper on selected results of the 3rd Delphi round for the CSCL conference in summer 2011 (Kaendler et al., accepted).

2 The 2nd STELLAR Delphi Round – First Global Survey

This chapter focuses on the results of the first of two global surveys, the 2nd STELLAR Delphi round. The planning, recruiting, and the questionnaire design process of this round were presented in detail in D1.3 (Spada et al., 2010); therefore, we restrain the presentation of these aspects to a short summary in the following section.

2.1 Panel of Experts and Questionnaire

In February 2010, we invited 511 TEL experts to participate in the online survey. 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 (see Appendix A). Most of the European countries, America, Asia, and Australia were represented.

The first part of the questionnaire (see Table 1, p. 14) was composed of rating items on future trends that were based on the topics and subtopics identified in the 1st STELLAR Delphi round. The experts were asked to evaluate the importance of future societal demands and challenges, the impact of technological developments, and the importance of future research themes. In the following, we refer to these three dimensions as *Future Trends*. In the second part of the questionnaire, 16 Visionary Statements were rated for their desirability and their likeliness to become reality by 2025. A *Visionary Statement* portrays a fraction of a future scenario within a specific time frame, in this case, within the time frame of 15 years.

On each of the three pages of the survey concerning the Future Trends, the experts were encouraged to supply missing societal challenges, technological developments, or research themes respectively. At the bottom of the pages in the survey portraying the Visionary Statements, the experts were given the opportunity to make comments explaining or justifying their ratings in an open text field. After having rated the 16 Visionary Statements, the experts could provide up to three new Visionary Statements of their own (see also D1.3, chapter 6).

2.2 Results of the 2nd Delphi Round – Future Trends and Visions

In the following sections, we start the presentation of the results by giving a short overview of the characteristics of the dataset. Next, we describe the results of the Future Trends (see chapter 2.2.2) and the Visionary Statements (see chapter 2.2.4) in depth. At the end of each of these detailed descriptions, we summarize the results for the Future Trends (see chapter 2.2.3) and the Visionary Statements (see chapter 2.2.5), respectively.

2.2.1 Characteristics of the dataset

Table 1 gives an overview of the item formats employed in the 2nd Delphi round for the Future Trends and the Visionary Statements, the resulting type of data (quantitative vs. qualitative), and the data analysis applied. The dataset of the 2nd STELLAR Delphi round comprises both quantitative data derived from the rating items and qualitative data that was collected through the open text fields on the Future Trends and the Visionary Statements. The analyses reported in the following sections are focused on the quantitative data while drawing on the qualitative data for supporting the quantitative findings.

We analyzed the quantitative data of the 2nd STELLAR Delphi round with a repeated-measure analysis of variance (ANOVA). The repeated-measure factor represents different dependent variables, namely the different rating items that were answered for each of the questions. For example, we examined whether the experts rated the items significantly different from each other. A significant main effect of the repeated-measure factor indicates that the different rating items were not perceived as equally important or influential.

Not all experts completed each part of the questionnaire; the exact number of experts who provided ratings to a specific question is reported in the according paragraph. The effect sizes were calculated using Cohen's formula $f = [(\eta_p^2/(1-\eta_p^2)]^{½}$ (Cohen, 1988). The magnitude of effect sizes are based on the classification of Cohen (1988, 1992): $f > .10$ for a small effect, $f > .25$ for a medium effect, $f > .40$ for a large effect.

Table 1. *Overview of the Data of the 2nd STELLAR Delphi Round.*

Question	Item format	Data	Data analysis
Future Societal: "What key societal demands and challenges will Technology-Enhanced Learning have to respond to in the future? "	*18 rating items* with a scale for *importance* ranging from *not* (1) to *very* (5) important	quant.	Statistical analysis (ANOVA, descriptive analysis)
	"Please provide additional future societal demands & challenges that you consider important but are missing above" *Text field for written input*	qual.	Coding with the category system developed in the 1st Delphi round; extension of categories for additional input
Future Technological: "What key technological developments will have an impact on Technology-Enhanced Learning in the future?"	*12 rating items* with a scale for *impact* ranging from *no* (1) to *high* (5) impact	quant.	Statistical analysis (ANOVA, descriptive analysis)
	"Please provide additional future technological developments that you think will have a high impact but are missing above" *Text field for written input*	qual.	Coding with the category system developed in the 1st Delphi round; extension of categories for additional input
Future Research: "Imagine a large international research program on Technology-Enhanced Learning to be carried out from 2015 till 2020: What should be central research themes in this program?"	*25 rating items* with a scale for *importance* ranging from *not* (1) to *very* (5) important	quant.	Statistical analysis (ANOVA, descriptive analysis)
	"Please provide additional research themes that you consider important but are missing above" *Text field for written input*	qual.	Coding with the category system developed in the 1st Delphi round; extension of categories for additional input
16 Visionary Statements: "In the last part of the survey, we would like you to rate visionary and/or controversial statements regarding future developments in TEL."	*Rating scale on likelihood* to become true ranging from *unrealistic* (1) to *realistic* (5)	quant.	Statistical analysis (ANOVA, descriptive analysis)
	Rating scale on desirability ranging from *undesirable* (1) to *desirable* (5)	quant.	Statistical analysis (ANOVA, descriptive analysis)
	"You can add a comment to the statements or your ratings" *Text field for written input*	qual.	Comments are taken into account for discussion of results
	"Please provide 2 to 3 additional 'Visionary Statements' regarding future developments in TEL with a high potential impact." *3 text fields for written input*	qual.	Categorization into clusters for controversial areas - Areas of Tension (this process is described in chapter 3)

2.2.2 Evaluation of the Future Trends

First, we describe the analysis of the Future Trends including inferential and descriptive statistics. The following research questions were investigated:

- Overall, do the expert ratings on the importance of the societal challenges differ significantly?
- Overall, do the expert ratings on the impact of the technological developments differ significantly?
- Overall, do the expert ratings on the importance of the research themes differ significantly?

The analyses aimed at identifying mean differences in the ratings on importance/impact between the questionnaire items for each of the questions on Future Trends individually. In other words, we investigated whether the experts evaluated items within a question to be of different importance.

We conducted three individual one-way repeated-measure analyses of variance. The repeated-measure, that is, the within-subjects factor, is the rating items of the Future Trends. The subjects, that is the experts, were entered as the independent variable in the ANOVA and the ratings were entered as the dependent variable.

Even though the focus was on the quantitative analysis, we also took the qualitative data into account in the data analysis process. Prior to the statistical analysis of the quantitative data of the Future Trends, the qualitative data on the additional input to the Future Trends was analyzed. We applied the category systems from the 1st Delphi round (see Deliverable 1.3) to assign topics or subtopics to the additional input of the experts of the 2nd Delphi round. For statements that did not fit any of the existing topics, new coding categories, that is topics or subtopics, were created and complement the description of the results in the following sections.

In the following sections, questionnaire items are indicated by quotation marks and topics/subtopics are indicated by italic print.

2.2.2.1 Importance of future societal challenges and demands

The ratings that were provided by 209 experts were entered in the ANOVA investigating societal challenges and demands. One of the fundamental assumptions of the analysis of variance is sphericity. For the analysis that we conducted, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(152) = 521.33$, $p < .001$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity, $\varepsilon = .74$. The ANOVA revealed a significant main effect of the repeated measure, namely the 18 Future Societal items, on the value of the importance-ratings, $F(12.6, 2623.6) = 30.15$, $p < .001$, $f = .38$. This medium effect indicates that the ratings on the societal challenges differ significantly from each other. In order to further explore the significant main effect, we examined the graphical representation of the data, that is, the bar graphs of the mean scores including the standard deviations. This enabled us to identify the major differences between the ratings of the questionnaire items. The descriptive statistics were the backbone of this heuristic analysis approach.

Table 2 illustrates the topics of the 1st Delphi round from which the questionnaire items were derived. Figure 3 illustrates the mean scores and standard deviations of the Future Societal items (labeled as *Societal 1 - 18*) that were rated by the experts in the 2nd Delphi round. The Future Societal questionnaire items are ordered according to the topics from which they were derived (see Table 2).

Table 2. *Means, Standard Deviations: Importance of Societal Challenges & Demands.*

Topics (1st Delphi round results)	**Item** #	**Questionnaire items** (2nd Delphi round)	**Importance** *M*	*SD*
Social justice	14	Integrate diverse groups of people into society and the educational system with the help of technology	3.78	0.93
	9	Reducing the "digital divide" (accessibility to digital resources)	4.07	0.91
Knowledge society and its demands for education	1	Adapt education to new generations of students (e.g. "digital natives" that grew up with technology)	4.11	1.00
	11	Adjust education to the “knowledge/information society” (e.g. quick, dynamic changes of knowledge)	3.87	1.07
	8	Teach media and information literacy	3.93	0.94
Demographic developments	12	Aging society (different needs of older people)	3.61	0.95
	5	Job market changes (e.g. job profiles and requirements)	3.68	0.97
	10	Gap between young and old people	3.34	0.93
Improve formal education	15	Adapt education to individual needs to improve formal education	4.00	0.96
	2	Provide teacher training in order to improve formal education	4.18	0.86
Lifelong learning & workplace learning	3	Lifelong learning	4.27	0.77
	7	Learning on demand	4.04	0.87
Global political challenges	13	Environmental challenges (e.g. climate change)	3.34	1.26
Globalization of business and education	16	Globalization of education (both provision of education and global distribution of learners)	3.74	0.98
Informal Learning	17	Connection between formal & informal learning	3.95	0.97
	18	Accreditation of informal learning	3.25	1.10
Ubiquitous technology	/	/	/	/
Change in societal values	/	/	/	/
Political usage of new media	4	Political usage of new media	3.21	1.03
Privacy on the Internet	6	Privacy issues on the Internet	3.87	1.01

Note. The answers were given on a five-point rating scale from *not* (1) to *very* (5) *important*.

First of all, it has to be noted that most of the societal challenges and demands were rated as rather important. Nevertheless, for all 18 Future Societal items, all rating options from *not* to *very* important were chosen by at least one of the experts, indicated by a range of 4. When looking at the bar graphs (see Figure 3) and the descriptive statistics, four items - Societal 4, 10, 13, and 18 (“political usage of new media”, “gap between young and old people”, “environmental challenges”, “accreditation of informal learning” respectively) – appear to have been evaluated as less important in comparison to the other items. The mean scores of these four items range from 3.21 to 3.34. However, it has to be taken into account that the item “environmental challenges” (Societal 13) shows the largest standard deviation (*SD* = 1.26), indicating that the experts did not fully agree on the importance of this societal challenge.

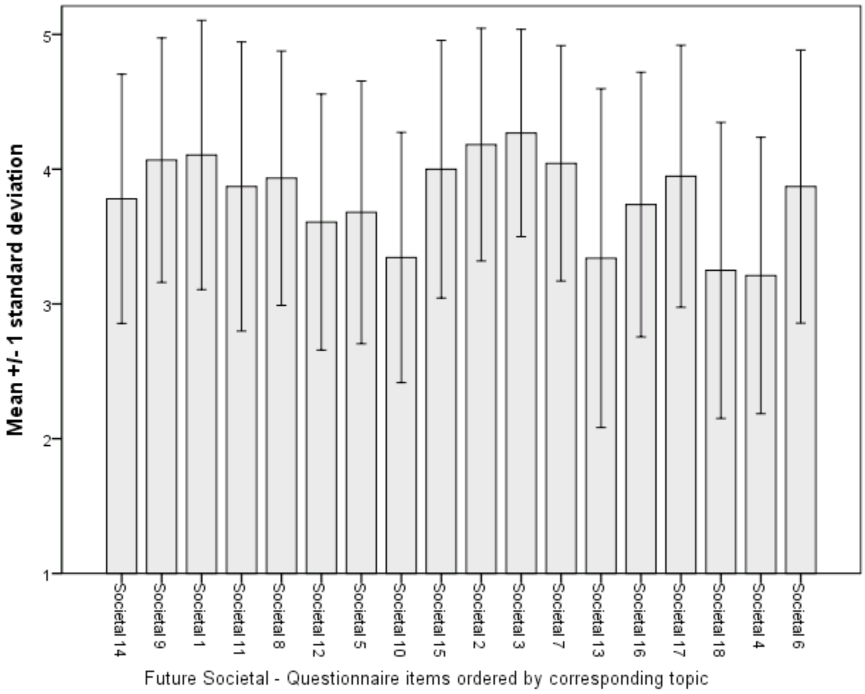

Figure 3. Future Societal Results - Bar Graphs (Means and Standard Deviations of the Importance Rating).

On the other side, six items – Societal 1, 2, 3, 7, 9, and 15 (“adapt education to new generations of students”, “provide teacher training in order to improve formal education“, “lifelong learning“, „learning on demand“, „reducing the ‘digital divide’”, and “adapt education to individual needs to improve formal education“ respectively) – were rated as being very important with mean scores between 4.0 and 4.27. In addition to having been rated as very important, the two items on *lifelong & workplace learning* have small standard deviations (*SD* = 0.77, *SD* = 0.87) pointing to a high agreement among the experts on the high importance of the role of lifelong & workplace learning for TEL research.

When looking at the graphical representation of the data, five items appear very close to the items identified as the most important societal challenges and demands. Societal 6, 8, 11, 14, and 17 (“privacy issues on the Internet“, „teach media and information literacy“, „adjust education to the ‘knowledge/information society’ [e.g. quick, dynamic changes of knowledge] “,“integrate diverse groups of people into society and the educational system with the help of technology“, and “connection between formal and informal learning“ respectively) show mean scores between 3.78 and 3.95; thus, these items were rated almost as important as the six already mentioned most important societal challenges and demands.

Taking into account both the items that were rated just below the cut-off to the most important items and the most important items, the panel of experts advocated that TEL research had to respond to topics of societal challenges or demands (see Table 1, *topics*) such as social justice, the knowledge society and its demands for education, the improvement of formal education, and lifelong & workplace learning. These important challenges and demands are closely followed by the societal challenge of privacy issues on the Internet and the connection between informal and formal learning. The less important societal challenges and demands concern the topics demographic developments, global political challenges, and informal learning.

Additional Input to Future Societal Challenges and Demands

Sixty-eight experts contributed additional input to the societal challenges and demands in the open text field below the Future Societal rating items. The textual input was segmented into 95 units of meaning. A lot of statements from the experts could be coded into the existing topics from the 1st Delphi round; mostly, these statements presented novel aspects to the existing topics. For example, the topic *social justice* was extended with statements that asked for the *differentiation between digital divide* in general and *digital literacy divide*. Especially novel aspects of the topic *knowledge society and its demands for education*, for example adjusting education to 21st century skills or new generation of teachers in addition to new generations of students, were mentioned by the experts. The additional input on the topic *improving formal education* mainly addressed the need to bridge learning in school with learning at home and parental/legal guardian involvement in learning.

The coding of the additional input from the experts of the 2nd Delphi round to the Future Societal questionnaire items showed that *mobility of the society*, transformation of formal education systems, collaborative learning and less investment in higher education due to public sector debt represent societal demands and challenges that the experts considered to be important for future TEL research and that were missing among the rating items.

2.2.2.2 Impact of future technological developments

For the investigation of ratings on the future technological developments, the data of 214 experts were entered in the ANOVA. Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(65) = 234.5$, $p < .001$. As ε exceeded .75 (ε = . 85), we corrected the degrees of freedom using Huynh-Feldt estimates of sphericity. The analysis of the repeated measure factor revealed that the impact ratings on technological developments differ significantly from each other, $F(9.36, 1994.3) = 49.68$, $p < .001$, $f = .48$ (large effect).

As mentioned before, we examined the graphical representation and the descriptive statistics of the data for identifying the relevant differences between the ratings of the Future Technological questionnaire items, which were indicated by the significant main effect.

Table 3 illustrates the topics of the 1st Delphi round from which the questionnaire items were derived. Figure 4 illustrates the mean scores and standard deviations of the Future Technological items (labeled as *Technological 1 - 12*) that were rated by the experts in the 2nd Delphi round. The Future Technological questionnaire items are ordered according to the topics from which they were derived (see Table 3).

It has to be noted that overall most of the technological developments were seen as rather influential for the future of TEL research. All but one Future Technological item have a range of 4; thus all rating options ranging from *no* (1) to *high* (5) impact were chosen at least once by the experts. The item Technological 6 ("innovative interfaces [e.g. more intuitive to interact with]") was rated only on options 2 to 5 of the 5-point rating scale; hence no expert chose this technological development to have no impact on TEL research. According to the graph and the descriptive statistics, the future technological developments that have the highest impact on TEL research according to the panel of experts show mean scores ranging from 4.21 to 4.37: Technological 1, 3, and 9 ("technology spread", „mobile (portable) computing technologies", and "collaboration & communication tools" respectively). These items also show relatively small standard deviations ranging from 0.78 to 0.89. The most influential technological developments are closely followed by the items Technological 5, 6, and 7 ("Web 2.0 applications & user-generated content", "innovative interfaces", and "interoperability between technological devices" respectively) with mean scores between 3.96 and 4.07. From the bar graphs, it can be seen that two items seem to fall short on the impact-rating compared to the other Future Technological items: Technological 10 and 11 ("sensor technology" and "Web 3D") reached mean scores of 3.17 and 3.35 respectively.

Table 3. *Means and Standard Deviations: Impact of Technological Developments.*

Topics (1st Delphi round results)	**Item #**	**Questionnaire items (2nd Delphi round)**	**Impact** *M*	*SD*
Ubiquitous & contextualized learning and technology	3	Mobile (portable) computing technologies	4.37	0.78
	12	Context-aware technologies and applications	3.89	0.94
New ways of human-computer interaction & ambient computing	8	Ambient intelligence/computing (e.g. objects or environments of networked devices that recognize people and react to their presence)	3.69	1.00
	10	Sensor technology	3.35	0.96
	6	Innovative interfaces (e.g. more intuitive to interact with)	4.07	0.86
Interoperability and the integration of different devices & applications	7	Interoperability between technological devices	3.96	0.95
Web 2.0 & social software	5	Web 2.0 applications & user-generated content	4.02	0.88
Augmented & virtual reality	2	Augmented & virtual reality	3.61	0.95
	11	Web 3D	3.17	1.01
Future of the Web	4	Semantic Web (a web including the meaning of the information - not just links between web pages - making it possible to satisfy search requests on a higher level)	3.79	0.96
Technology in education /educational technology	/	/	/	/
Collaboration & communication tools	9	Collaboration & communication tools (e.g. increasing communication tools for distance learning/collaboration such as Google wave)	4.21	0.89
Technology spread	1	Technology spread (smaller, cheaper, easier technological tools)	4.35	0.78
Cloud computing	/	/	/	/

Note. The answers were given on a five-point rating scale from *no* (1) to *high* (5) *impact*.

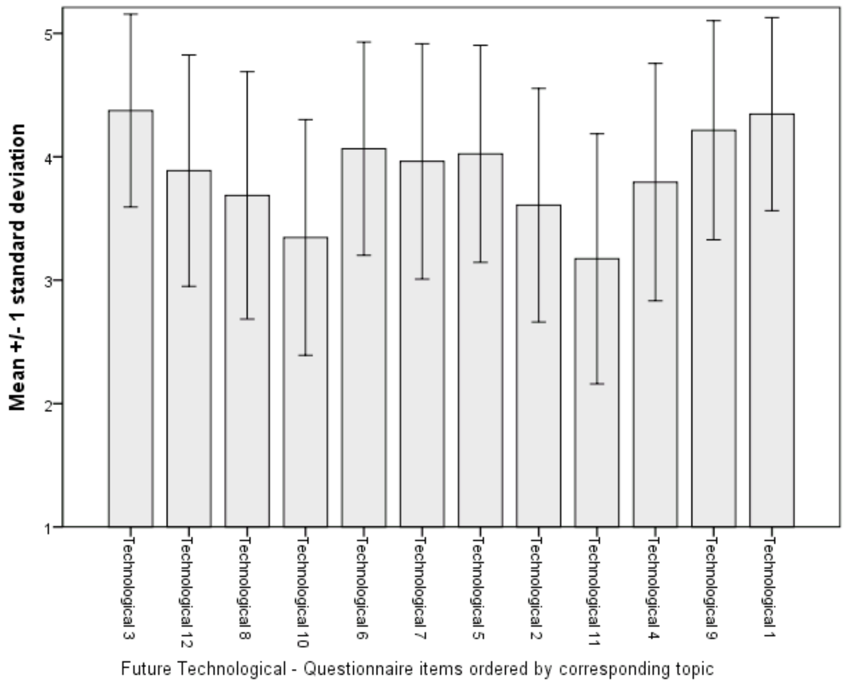

Figure 4. Future Technological Results - Bar Graph (Means and Standard Deviations of the Impact Rating).

The topics of the 1st Delphi round (see Table 3) that were associated with the most influential technological developments are *ubiquitous & contextualized learning and technology*, technology spread, and collaboration and communication tools. The topic new ways of human-computer interaction & ambient computing was evaluated on three items in the questionnaire out of which innovative interfaces was rated as influential whereas sensor technology was estimated as having less impact on TEL research.

Additional Input to Future Technological Developments

Out of 214 experts who rated the Future Technological items, 38 experts provided additional technological developments they felt were missing among the questionnaire items. The segmentation of the statements led to 55 units of meaning. Some statements from the experts were coded into the existing topics from the 1st Delphi round. For example, statements stressing the impact of gesture- or speech-controlled interfaces were coded into the topic *new ways of human-computer interaction & ambient computing*. Further, the topic *ubiquitous & contextualized learning and technology* was complemented with the idea of geotagging or geocaching. Even though the topic *technology spread* was presented as an item of the questionnaire, the experts provided statements accentuating its impact on TEL in the open text field.

The coding of the additional input to the Future Technological questionnaire items revealed additional technological developments such as *authoring tools and personalization*, *serious games,* and *adaptive intelligent learning support* that have to be considered for future TEL research. Even further, the experts advocated that *synergies from innovative interdisciplinary research (neuroscience, biological computing, robotics, etc.)* should be aimed for in order for TEL research to build upon and contribute to game-changing research.

2.2.2.3 Importance of future research themes

Overall, 189 experts rated all the Future Research items and their data were entered in the ANOVA investigating the rating on future research themes. As with the aforementioned analyses, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(299) = 916.45$, $p < .001$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity, $\varepsilon = .67$. The ANOVA revealed a significant main effect of the repeated measure, that is, the 25 Future Research rating items, on the value of the ratings on importance, $F(16.1, 3028.3) = 12.57$, $p < .001$, $f = .26$. This medium effect shows that the importance-ratings of the future research themes significantly differ from each other.

Table 4 illustrates the topics of the 1st Delphi round from which the questionnaire items were derived. Figure 5 illustrates the mean scores and standard deviations of the Future Research items (labeled as *Research 1 - 25*) that were rated by the experts in the 2nd Delphi round. The Future Research questionnaire items are ordered according to the topics from which they were derived (see Table 4).

Table 4. *Means and Standard Deviations: Importance of Research Themes.*

Topics (1st Delphi round results)	**Item** #	**Questionnaire items** (2nd Delphi round)	**Importance** *M*	*SD*
Ubiquitous & contextualized learning and technology	14	Contextualized learning & context-aware applications	3.92	0.96
	7	Ubiquitous & mobile technology/learning	3.89	0.97
Improve formal education	24	Improve practices of formal education & formal education systems	3.74	1.00
	10	Integration of technology into formal education settings	3.80	0.99
	2	Teacher training	3.72	1.03
	4	Teaching of TEL-skills	3.21	1.06
Characteristics of the research program (connected to TEL as a research field)	/	/	/	/
Instructional methods & frameworks	1	Development of/research on instructional objectives & frameworks	3.25	1.13
	18	Development of/research on instructional methods & applications	3.70	1.07
Collaborative learning	20	Analysis of cognitive processes on the group level	3.81	0.99
	25	Collaborative learning	4.11	0.87
	12	Collective intelligence/wisdom of the crowds	3.41	1.14
Informal learning	8	Connection between formal and informal learning	3.84	0.98
	11	Informal learning	3.78	0.95
Personalization / individualization	19	Personalization/individualization of learning (e.g. PLE)	3.94	1.01
Social justice	22	How can we address the needs of all learners	3.80	0.98
	13	Social justice/addressing the digital divide (accessibility to digital resources)	3.58	1.03
	15	Enabling Third World Countries to benefit from technology-enhanced learning	4.03	0.94
Lifelong learning & workplace learning	6	Lifelong learning & workplace learning	3.92	0.88
Emotional and motivational aspects	23	Emotional & motivational aspects of learning	3.85	1.01
Social software	17	Social software	3.59	1.01
Adaptive/intelligent learning support systems	9	Adaptive/Intelligent learning support systems	3.84	1.07
Competence assessment techniques	5	Competence assessment techniques	3.42	1.02
Open access to information resources and tools	21	Open access to information resources and tools	3.69	0.95
Recommender systems	3	Recommender systems (e.g. based on a student's previous learning experience a system recommends matching learning objects)	3.38	1.00
Interoperability and the Integration of different devices & applications	16	Interoperability and the integration of different devices & applications	3.65	1.06

Note. The answers were given on a five-point rating scale from *not* (1) to *very* (5) *important*.

When looking at the bar graphs in Figure 5, it can be seen that almost all of the future research themes were rated as being rather important. However, investigating the graphical representation and the descriptive statistics in more detail, two items can be identified as the most important research themes: Research 15 and 25 (“enabling developing countries to benefit from technology-enhanced learning“ and “collaborative learning“ respectively). Both items show relatively high mean scores, M = 4.03 and M = 4.11, respectively. Additionally, the Future Research item “collaborative learning” that was rated highest on importance for TEL research also showed the lowest standard deviation, SD = 0.87. When looking at the bar graphs, besides the two mentioned items, a large number of items seem to stand out in comparison to the other items. These items are Research 2, 6, 7, 8, 9, 10, 11, 14, 18, 19, 20, 22, 23, and 24 (“teacher training“, „lifelong learning & workplace learning“, “ubiquitous & mobile technology/learning“, “connection between formal and informal learning“, “adaptive/intelligent learning support systems“, “integration of technology into formal education settings“, “informal learning“, „contextualized learning & context-aware applications“, “development of/research on instructional methods & applications“, “personalization/individualization of learning“, “analysis of cognitive processes on the group level“, “how can the needs of all learners be addressed“, “emotional and motivational aspects of learning“, and “improve practices of formal education & formal education systems” respectively). This set of items was evaluated to have a fairly high importance on the rating scale with mean scores between 3.70 and 3.94.

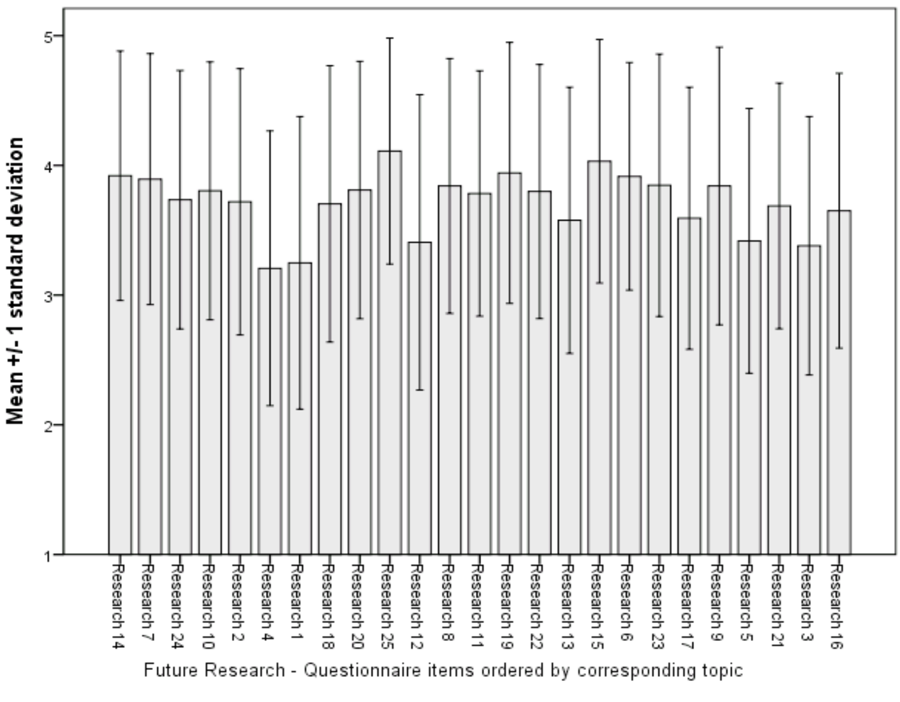

Figure 5. Future Research Results - Bar Graph (Means and Standard Deviation of the Importance Rating).

On the lower bound, the five items Research 1, 3, 4, 5, and 12 (“development of/research on instructional objectives & frameworks“, “recommender systems“, “teaching of TEL-skills“, “competence assessment techniques“, “collective intelligence/wisdom of the crowds“, respectively) appear to have been rated as less important for TEL research compared to the other research themes showing mean scores ranging from 3.21 to 3.42.

The ratings of the Future Research items 13 and 17 (“social justice/addressing the digital divide [accessibility to digital resources]” and “social software”) appear to fall in between the important and less important items.

Additional Input to Future Research Themes

Seventy-six units of meaning were segmented from the textual input of 44 experts to the Future Research items. The experts provided statements that contributed to existing topics of the 1st Delphi round by extending the scope of the corresponding topic. For example, the experts encouraged research for supporting teachers in orchestrating and assessing learning in the classroom. Furthermore, the perspective on emotional and motivational aspects in the learning process was extended to incorporate learners’ attitudes and their effect on engagement and learning.

The coding of the additional input to the Future Research questionnaire items revealed additional research themes that were mentioned by multiple experts, such as the integration of findings from neuroscience/-psychological into research on TEL, the investigation of the effects of IT on learners (short-/ and long-term), and serious games.

2.2.3 Summary of the results of the Future Trends

The 2nd Delphi round aimed at identifying important research themes for the future of TEL research, future technological developments affecting TEL, and important societal challenges and demands for TEL. In this section, the results of the 2nd Delphi round are summarized across the three questions on Future Trends in order to present a comprehensive overview.

First of all, a general remark concerning the results of the Future Trends has to be made: At first glance, the results of the Future Trends appear to draw a rather homogenous picture which depicts solely important or influential trends, especially for the future research themes. Because the rating items resulted directly from the data/results of the 1st Delphi round, the high ratings in the 2nd Delphi round indicate that the future trends suggested by the STELLAR members in the 1st Delphi round were confirmed and validated by the large, global panel of experts. In short, in the context of the STELLAR Delphi study, these results underline the validity of the results of the 1st STELLAR Delphi round.

As already mentioned, almost all the research themes were evaluated as being very important; nevertheless, two topics stood out and were evaluated as being extremely important for a future research program, namely *collaborative learning* and *enabling developing countries to benefit from TEL*. In accordance with the report of the Beyond Current Horizons project, the experts of this Delphi round advocate that collaborative learning plays a major role for the future of learning (Facer & Sandford, 2010). The experts perceived collaborative learning to be an important research theme in the future of TEL research that is accompanied by the matching influential technological development of collaboration and communication tools. In addition to the notion of virtual collaboration of learners, the experts' vision for collaborative learning in the future also seems to refer to technologically augmented face-to-face collaboration. Thus, the integration of technology in collaborative learning settings could be seen critical if it entails only virtual interactions and neglects face-to-face communication. The impact of the increasing technology spread on the availability of mobile devices that enable access to the Web and the improved interoperability between multiple devices might foster effective collaborative learning with information and communication technologies (ICT). In this context, collaborative mobile learning can be seen as a new way of combining the advantages of both the pedagogical method of collaborative learning and the technological progress in the mobile and portable computing sector (cf. Jarvela, et al., 2007).

The second most important research theme *enabling developing countries to benefit from TEL* was reflected in the rating of the societal demand for reducing the digital divide. The high ratings of these items showed that the experts in this global survey were well aware of the growing population of digital natives and the necessity to respond to the societal challenge of adapting education to new generations of students. The experts advocated that despite the growing number of digital natives, teaching of digital literacy skills will become even more important in the future. In order to reduce the digital divide, further investigations of its actual effect on learning and of interventions that are effective to overcome the digital literacy divide are needed (cf. Pollard & Pollard, 2004). Overall, the experts acknowledged the digital divide and the importance to act upon it became evident. However, some experts also stressed that the digital divide is only one facet of social injustice that can be addressed by TEL research and the reliance on the proliferation of technology to overcome this inequity might not reach far enough.

Apart from these two research themes that stood out, a set of almost equally important research themes were identified. For example, in the 1st Delphi round, the topic of *personalization and individualization of learning* had already been evaluated to play an important role for future TEL research. The same trend was found in the ratings of the global panel of experts as well as in the additional input they provided. The experts stated that the topics technological development of authoring tools and personalization of technology were missing from the items presented in the question on future technological developments.

In addition to the mentioned societal challenges and demands for TEL, the experts agreed that TEL has to respond to the challenge of supporting learners in their efforts for *lifelong learning* through the promotion of research on this topic. In the report of the Beyond Current Horizon Project (Facer & Sandford, 2010), lifelong learning is described as involving mainly networked learning activities; thus the technological development of *Web 2.0 applications or user-generated content* for supporting lifelong learning seems to be an evident trend that was also confirmed by the experts of the 2nd Delphi round. Lifelong learning seems to be closely tied to *workplace learning*, in the sense that businesses expect their employees to constantly improve their skills and enlarge their knowledge. In order to enable learners to be flexible in their access to learning resources, the *interoperability of devices and applications* throughout a lifetime will become indispensable.

One of the technological developments that were seen to have a high impact on the future of TEL is *innovative interfaces* for facilitating human-computer interactions. Interdisciplinary research advances on this topic were seen as promising. The experts expressed high expectations concerning the potential of developments in speech and gesture-controlled interfaces for the next step in designing educational technology. This topic was also covered in the Horizon Report in 2010 (Johnson, Levine, Smith, & Stone, 2010).

The additional input on the technological developments brought forward the concept of game-based learning. The experts envisioned that serious games might help to overcome the issue of students' lack of motivation in the learning subject and that game-based learning might suggest an alternative approach to learning with ICT in the future. The experts' evaluated the closely related research theme *emotional and motivational aspect of learning* to be a promising area of future TEL research. Research in this area will provide evidence and insights in the factors and underlying aspects of learning apart from the cognitive aspects of learning.

In this section, we summarized the results of the Future Trends and presented emerging interrelations between the ratings of the research themes, technological developments, and societal challenges and demands.

2.2.4 Evaluation of the Visionary Statements

In this section, we report the results of the Visionary Statements which were evaluated for differences in the experts' estimations on the realistic/desirability dimension. Additionally, the descriptive analysis identified types of distributions, for example whether some statements were rated as being very realistic but not desirable.

The analysis of experts' responses to the 16 selected Visionary Statements aimed at detecting patterns within the ratings on both rating scales. In particular, we were interested in the homogeneity versus heterogeneity in experts' opinions: How uniformly would experts rate a given Visionary Statement with regard to its likelihood to become reality and with regard to its desirability? Relevant tensions in TEL would manifest themselves in dispersed distributions of experts' answers, whereas homogenous opinions would manifest themselves in distributions of answers that would be heavily skewed towards a certain position. In addition, the experts' written comments on the Visionary Statements were screened for additional information indicating tensions in TEL.

We computed one-way repeated-measure analyses of variance to investigate the differences between the realistic-ratings (data of 211 experts) and desirability-ratings (data of 203 experts) on the Visionary Statements respectively. The repeated measure, that is, the within-subjects factor, was the rating items of the 16 Visionary Statements. The ANOVAs revealed two large significant main effects of the repeated measure; realistic-rating items: $F(1, 14.01) = 62.97$, $p < .001$, $f = .55$ and desirability-rating items: $F(1, 13.37) = 199.08$, $p < .001$, $f = .99$. These two large main effects imply that the expert ratings of the 16 Visionary Statements varied significantly for the different statements.

Table 5. *2nd STELLAR Delphi Round – 16 Visionary Statements (MD denotes median, V skewness, M mean, SD standard deviation)*

Item	Questionnaire Items of the 2nd Delphi Round	realistic / desirable	*MD*	*V*	*M*	*SD*
1	By 2025, virtual experiences will dominate education.	realistic	3	0.03	2.88	1.17
		desirable	2	0.27	2.43	1.11
2	By 2025, formal education of long running mass programmes will become irrelevant in favour of networked and digitally supported personal learning trajectories.	realistic	3	0.04	2.88	1.16
		desirable	3	-0.18	3.15	1.27
3	By 2025, learning to type-write will replace learning to hand-write in early education.	realistic	3	-0.12	3.09	1.30
		desirable	2	0.59	2.28	1.18
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.	realistic	4	-0.51	3.57	1.03
		desirable	4	-0.84	3.95	0.95
5	By 2025, no content needs to be memorized because wearable context-aware devices will provide the relevant information.	realistic	3	0.20	2.70	1.30
		desirable	2	0.90	2.07	1.13
6	By 2025, our learning history will be recorded resulting in a track record (including video) for example for evaluation purposes.	realistic	4	-0.45	3.42	1.22
		desirable	3	-0.06	3.00	1.21
7	By 2025, key developments in TEL will mainly come from the gaming and entertainment industry.	realistic	3	-0.28	3.23	2.32
		desirable	2	0.21	1.13	0.95
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.	realistic	4	-0.45	3.33	1.24
		desirable	4	-0.47	3.52	1.10
9	By 2025, learners will be empowered to design their own think tools	realistic	4	-0.54	3.30	1.17
		desirable	4	-0.92	4.01	1.02
10	By 2025, intelligent software will support learners to filter information for quality and importance.	realistic	4	-1.15	4.03	1.03
		desirable	4	-1.26	4.11	1.09
11	By 2025, inexpensiveness and ease of use of technology will enable diverse groups of people to access educational resources.	realistic	4	-1.03	4.03	1.03
		desirable	5	-2.12	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).	realistic	3	-0.42	3.37	1.31
		desirable	3	0.09	2.83	1.30
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.	realistic	2	0.54	2.27	1.21
		desirable	1	2.20	1.37	0.76
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....	realistic	4	-0.92	3.94	1.06
		desirable	4	-0.76	3.76	1.16
15	By 2025, the boundary between formal and informal learning will have been blurred.	realistic	4	-0.83	3.73	1.12
		desirable	4	-0.94	3.92	1.07
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…).	realistic	4	-1.51	4.27	0.87
		desirable	4	-1.04	4.20	0.85

The descriptive parameters median, skewness, mean, and the standard deviation (see Table 5) further illustrate the differences between the rating-items. The median score is the value that separates the upper and lower half of the sample, for example, a median of 3 signifies that 50% of the experts had 3 and higher values and 50% of the experts had 3 and lower values. The skewness scores indicate if the distribution of the ratings is skewed to either side of the scale. A skewness score smaller than 0 signifies a distribution that is skewed to the right hand side; a skewness score above 0 describes a distribution that is skewed to the left hand side.

Based on these descriptive parameters, we revealed patterns, that is, specific distributions, within the experts' ratings on the two rating dimensions *realistic* and *desirability* across the 16 statements. To illustrate one distribution of the experts' answers, Figure 6 shows the bar graphs for Visionary Statement 10. The bar graphs represent the percentage of experts who chose a certain rating option. The median for both scales is 4, indicating that half of the experts chose option 4 and 5. In line with the median score, both bar graphs show that the experts' ratings are skewed towards the far right side of the scales (skewness scores < 0). Taking both descriptive indicators together, we observe that this statement was evaluated to be very realistic and very desirable.

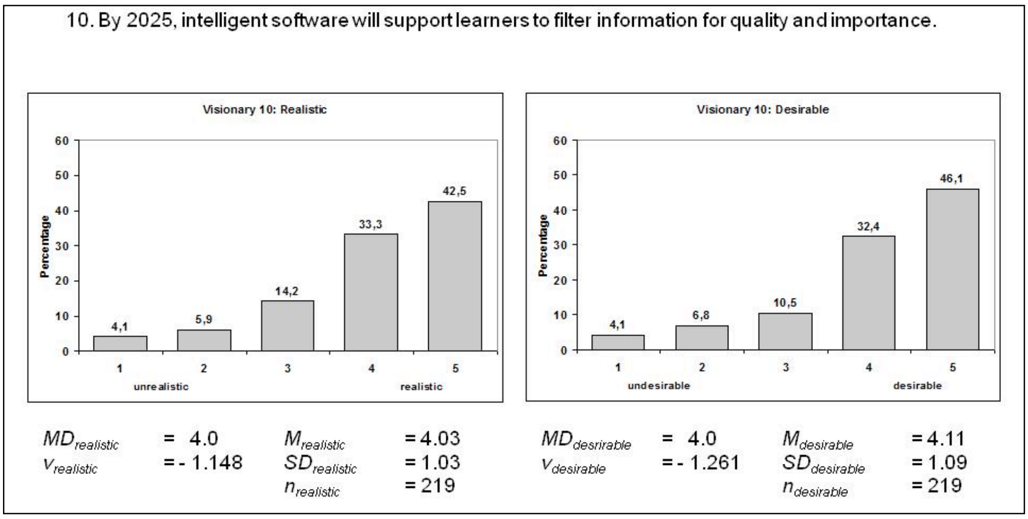

Figure 6. Exemplary bar graphs – Visionary Statement 10.

Four patterns of distributions on the two dimensions realistic- and desirability-rating across the 16 statements were identified: very realistic/very desirable, realistic/desirable, mixed realistic/mixed desirable, and unrealistic/undesirable. We classified the rated Visionary Statements based on a median score of over 3.0, 3.0, or smaller than 3.0 and a skewness score of smaller than 0, 0, or larger than 0. A median score over 3 and a skewness score smaller than 0 indicate that the ratings are skewed to the right hand side of the scale;

the respective Visionary Statements were therefore classified as the patterns very realistic/very desirable and realistic/desirable. In contrast, a median score smaller than 3 and a skewness score over 0 indicate that the ratings are skewed to the left hand side of the scale; Visionary Statements with such a rating were therefore classified as unrealistic/undesirable. The remaining distributions were classified as the pattern mixed realistic/mixed desirable indicating a wide range of different views on these statements. The 4 x 4 grid in Figure 7 illustrates the 16 possible types of frequency distributions. However, only seven types were detected in the data. Figure 7 shows the item numbers of the Visionary Statements that fall under each of the seven types. The miniature bar graphs symbolize the corresponding trend of the frequency distribution. When moving from left to right on the *x*-axis, the realistic-/desirability-rating increases, that is, the experts rated the items to be desirable/realistic, whereas the bars near the origin of the diagram represent the lower rating values, that is, unrealistic/undesirable ratings. In the following sections, the different types of frequency distributions are described in more detail. For the purpose of this annex, we combined the description of type 1 to 3.

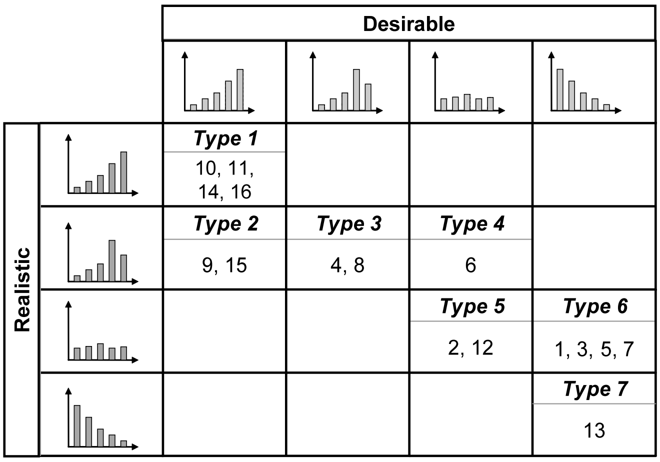

Figure 7. Visionary Statements – Types of Frequency Distributions.

The types, the corresponding Visionary Statements, and sample quotations are presented in the next sections.

2.2.4.1 Type 1, 2, 3 – realistic and desirable

Two out of the four statements clustered as Type 1 were considered to be particularly realistic and desirable by most experts (Type 1). They both concern future visions on the use of TEL for assessment purposes in formal educational settings: “By 2025, students' report cards will include assessment of domain-general skills, such as computer-literacy, collaboration skills, mastery of reading and learning strategies” (VS 14), and “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…])" (VS 16). Thus, the experts agreed upon the high desirability and likeliness of the technology-enhanced assessment of performance and higher-order skills in education. Further, the experts were very confident that by 2025, technology will support the learner by filtering content for quality and importance (VS 10).

Another Visionary Statement that was rated as both very realistic and very desirable (Type 1) deals with the topic of social justice that had also been judged as one of the most important research themes in the future of TEL (see chapter 2.2.3): "By 2025, inexpensiveness and ease of use of technology will enable diverse groups of people to access educational resources" (VS 11). The frequency distribution of the desirability-rating for this statement bears two outstanding characteristics: First, this statement was rated as most desirable with 80.5 % of the experts providing the highest rating score possible (5). Second, it is the only statement with a diminished range: only the option 3, 4, and 5 were chosen by the experts. In conclusion, the experts strongly value the goal of social justice.

Statements that were classified as type 2 or type 3 showed a drop on the last rating option for one or both rating scales. Thus, these statements were still rated as realistic and desirable, but with less extreme ratings.

First of all, the experts agreed upon the high desirability of individualization and personalization in the design and adaption of technology to individual preferences or needs (VS 9: "By 2025, learners will be empowered to design their own think tools"). A related statement that envisions developments in future human computer interaction, more particularly interface design, was also evaluated as realistic and desirable (VS 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"). In their comments to this statement, several experts noted that speech would be the innovative feature for interfaces of the future in addition to the ways of interacting with computers that were suggested in the statement.

Two other statements that were rated as both realistic and desirable deal with the connection between formal and informal learning. Two thirds of the experts viewed the blurring of boundaries between formal and informal learning as very desirable and also expected this to become reality by 2025 (VS 15: "By 2025, the boundary between formal and informal learning will have been blurred"). The second statement about formal and informal learning introduces the recognition of informally learnt skills and knowledge through technology: "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" (VS 4).

In summary, experts were quite optimistic about the future of TEL; many Visionary Statements were rated as both desirable and realistic. These statements covered aspects of fruitful use of technology in formal and informal education, but also an expected increase in social justice due to the increasing availability of TEL tools.

2.2.4.2 Type 4 – realistic and mixed desirability

For one of the statements, experts agreed that this development would quite certainly become reality in the future, but did not agree upon whether this would have desirable or undesirable consequences. This statement (VS 6) refers to the recording of the personal learning history and touches on issues of data privacy and security: "By 2025, our learning history will be recorded resulting in a track record (including video) for example for evaluation purposes". Some of the experts' comments illustrate the mixed ratings on the desirability scale by pointing out the possible downsides and by calling attention to the privacy issues associated with personal track records:

> "While the social software of the present is used to construct a kind of relatively public online history (e.g. Facebook), people will still value (and maybe come to value more) experience which is not observed by systems, not recorded, and not available to others."

Thus, the issue of data privacy in the context of data storage for TEL purposes represents a first tension in TEL.

2.2.4.3 Type 5 – mixed realistic and mixed desirability

For two of the statements, experts did neither agree in their desirability ratings nor in their ratings of how realistic they thought the statement was. Both Visionary Statements address issues of TEL in formal education: "By 2025, formal education of long running mass programmes will become irrelevant in favour of networked and digitally supported personal learning trajectories" (VS 2), and "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" (VS 12). The first statement stresses individualization and personalization of learning in higher education, whereas the second statement focuses on changes in K-12 education due to the adoption of technology. Both statements portray ratings that are almost evenly distributed among all options. The experts' comments provided insights in the reasons for their ratings. One expert draws attention to the many problems that we face today for implementing personal learning trajectories and that we still have to overcome in the future:

> "Personal learning trajectories appear a good idea and it is likely some experimentation will occur, but issues of formalizing qualifications, monitoring and designing systems that are automated enough to make this a realistic prospect in comparison with more formal teaching methods, except in certain disciplines and at certain levels, are so complex for underlying technology that large scale role out as a general method of education is very unlikely in such a small space of time" (Comment on VS 2)

Another expert points out that the integration of technology into formal education in the suggested way has consequences beyond improving or hindering learning:

> "Schools have important roles that are related to the direct interactions of the students and their teachers." (Comment on VS 12)

Thus, both the results from the rating analysis as well as the additional comments by the experts point towards two tensions in TEL: The complexity of the subject at hand and of the learning and administrative processes might compromise the implementation of personalized learning trajectories; the balance or imbalance between advantages and disadvantages resulting from the adoption of new digital tools for learning into the classroom to enable new methods of learning such as personalized learning.

2.2.4.4 Type 6 – mixed realistic and undesirable

There also was a group of statements for which experts agreed that they described undesirable trends; however, there was no consensus as to how realistic these undesirable trends were.

A first undesirable trend described the replacement of learning to handwrite by learning to type-write (VS 3): "By 2025, learning to type-write will replace learning to hand-write in early education". Some experts even went one step further and considered learning to type-write, just as learning to hand-write, to become unnecessary in the future since new desirable technological developments such as voice input would be replacing it. Most experts, however, deemed, handwriting to be an essential skill to be learnt in school:

> "The proposal underestimates the role of embodied learning which cannot be replaced by the use of technical devices. The practical experience of basic skills such as handwriting or mental arithmetic is not only a burden to be overcome but a gateway to a specific thinking and handling things"

Visionary Statement 5 ("By 2025, no content needs to be memorized because wearable context-aware devices will provide the relevant information") also animated the experts to think about which skills and abilities learners will have to master or will be offloaded to a technological device. The statement suggests that technology will be incorporated in ubiquitous, everyday objects and will help the learner to receive tailored information about his/her surroundings. Again, the experts differed in their evaluation of how likely this trend would become reality in the future. Further analysis of the comments provided by the experts revealed the low ratings on the desirability dimension to be due to the importance of prior knowledge for learning as indicated in the following comment:

> "I find this undesirable because (a) knowledge is the basis for critical thinking, complex decisions and complex problem solving (again, e.g., a doctor's decision which has to be taken under time pressure), (b) often, information is too complex to present it "on demand" so that a person can understand it immediately just from looking quickly on a (small) device."

The experts also evaluated a possible dominance of virtual experiences in education (VS 1: "By 2025, virtual experiences will dominate education".) as well as a growing influence and role of the gaming industry for developments in TEL (Visionary Statement 7: "By 2025, key developments in TEL will mainly come from the gaming and entertainment industry") as being undesirable; however the experts were indecisive about its likeliness to become reality. The following comment illustrates the shared view of the experts on the undesirability of this possible future vision:

> "While games technology provides many useful technological developments, the notion that education should be made more game-like is a delusion."

Thus, both the results from the rating analysis as well as the additional comments by the experts point towards two tensions in TEL: the role of ubiquitous, mobile devices in learning in the light of the acquisition of complex thinking skills and reflected learning experiences; and the impact of virtual experiences, for example through social media or educational games, on learning.

2.2.4.5 Type 7 – unrealistic and undesirable

Finally, there was only one statement that was judged to be both unrealistic and undesirable: "By 2025, microchips in our brain and drugs will allow us to control our mood, our motivation for learning and many other emotional aspects" (VS 13). The experts rejected this statement the most in terms of desirability compared to the ratings of the other statements. In their comments, several experts explained their low ratings on both scales to originate from the role of microchips in the statement:

> "It is very likely that drugs will be used to control mood, attention and so on, because they already are. It is much less likely that the 'microchips in the brain' trope will make it out of science fiction, given the emotional, technological and political responses such an idea regularly provokes."

2.2.5 Summary of the results of the Visionary Statements

The presented results of the 2nd Delphi round of the Visionary Statements illustrate that some visions for the future of TEL are seen as desirable and realistic (Type 1, 2, 3), whereas others do not portray such a clear picture (Type 4, 5, 6). Only one Visionary Statement was evaluated as undesirable and unrealistic (Type 7).

The Visionary Statements that could be categorized as type 1 to 3 indicated that the experts agreed upon the high likelihood of this statement for becoming reality and its high desirability.

Especially the aspect of reducing the digital divide by providing access to technological resources was advocated as a desirable development. The experts envisioned a future where increased access to educational resources for people in developing country would become a reality through the decreasing costs of technology. Even though the ratings show a strong agreement among the experts, the additional comments revealed an underlying tension which will be addressed in the conclusion (see chapter 2.3).

The experts also agreed on the high desirability of e-assessment in schools, not only for the assessment of knowledge but also for the assessment of higher order thinking skills such as mathematical reasoning.

Personalization and individualization of learning and the empowerment of the learner in the usage of technology was seen as a desirable and realistic trend; nevertheless, the experts rated the Visionary Statement dealing with the recording of the required data for adaptation as mixed-desirable. This indicates the experts' concern about privacy issues that could result from the handling of this data.

The experts' evaluations of the Visionary Statements that fall under type 4, 5, or 6 showed mixed results in the realistic- and/or desirable-ratings, which point towards controversial views on these topics among the experts. The tension that could be identified from the ratings of the Visionary Statements dealt with the introduction of technology in the classroom, the personalization of learning trajectories, the function and role of ubiquitous technology in learning, and the role of virtual experiences for learning processes.

According to the experts of the 2nd Delphi round, the transformation of the educational system seems to be an unstoppable trend. The experts agreed that the traditional educational setting of learning in the classroom will disappear and will be replaced by blended or online learning; nevertheless, the experts are ambiguous about the desirability of this development.

The experts were not in unison about the Visionary Statement on educational reforms in higher education. The Visionary Statement presented the idea of introducing personal learning trajectories instead of program-centered mass instruction. This Visionary Statement was evaluated towards both ends of the scale, which means that experts had opposing views on such reforms. In the comments, some experts pointed towards growing public debts in the educational sector which might result in less investment in and funding for education in general. To conclude, the formal educational landscape will change in the future; however, the direction it will turn to and the consequences cannot yet be predicted at this point. Even more so, research in this field and suggestions for desirable reforms are required in order to allow policy makers to reach informed decisions.

2.3 Conclusions – Promotion of Core Research Areas and Areas of Tension

The results of the 2nd Delphi round on Future Trends in TEL show that in general, there were 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 shows 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. In the summary of the results of the Future Trends, we demonstrated the interplay and interrelation between the research themes and the societal challenges and the technological developments. This interrelation justifies the promotion of specific Core Research Areas that can provide valuable guidelines for future work in these fields. Thereby, a *Core Research Area* represents a comprehensive research theme in integration with societal challenges to be addressed and technological developments.

The results of the 2nd Delphi round on the Visionary Statements clearly revealed underlying issues and tensions within certain areas of future TEL research as indicated by the mixed results for statements falling under type 4, 5, and 6. Though, it has to be noted, that the analysis of the qualitative data (comments on the Visionary Statements and additional visionary statements proposed) uncovered further issues underlying some of the Visionary Statements that were not apparent from the aggregated statistical measures. One of these underlying tensions can be exemplified for the Visionary Statement 11 dealing with social justice and the digital divide. Despite the extremely high ratings on both dimensions for this Visionary Statement, some experts were still hesitant about the actual influence and role of TEL in enabling diverse groups of learners to access educational resources:

> "Learners are not homogeneous and all exist on one side or the other of multiple digital divides, furthermore new technologies create new digital divides."

> "But...beware of second digital divide, if quality of use is not a focus. We need a firm purpose to achieve universal digital fluency."

The observed controversy between the ratings and the comments was found in the content of the additionally generated Visionary Statements. Taken these findings into account, an analysis of the underlying issues seems to be valuable for better understanding tensions in the area of TEL. In this line, the findings of the Visionary Statements led us to the conclusion that within certain areas of TEL research, experts hold opposing and conflicting views that can be manifested in so called Areas of Tension. Consequently, we define an *Area of Tension* to present two positions with opposing views on a certain issue within TEL or TEL research. Each position demands for different measures in order to solve or address the issue at hand. As an example, the tension between personalizing learning and data privacy contrasts the possibilities of adapting learning to individual preferences with the need for data privacy and security (see chapter 2.2.4.2). In the 3rd Delphi round, we further processed the presented results and analyzed the additionally proposed Visionary Statements for identifying Areas of Tension (see chapter 3.2.1).

The presented findings and conclusion of the 2nd Delphi round – the first global survey – provided the input for the 3rd Delphi round which aimed to identify Areas of Tension within TEL and to develop Core Research Areas for TEL. The next chapter describes the processing of the results of the 2nd Delphi round and the resulting Areas of Tension and Core Research Areas in more detail.

3 The 3rd STELLAR Delphi Round – STELLAR Workshops

The 3rd STELLAR Delphi round was a STELLAR-internal round and served to:

- reflect the results of the 2nd Delphi round with STELLAR partners,
- prepare the next and final global survey round (4th Delphi round),
- coordinate and integrate the various activities of work package 1 (WP1) with the other WPs

With these goals in mind, two workshops took place in Freiburg, Germany, in cooperation with the Bristol research team in July and August 2010. We contacted 14 STELLAR experts from 12 STELLAR partner universities/institutions. Altogether 13 STELLAR members came to Freiburg; each STELLAR instrument within WP 1 and each of the eight STELLAR WPs was represented. Seven experts attended each Delphi workshop; Rosamund Sutherland as the leader of the Bristol research team participated twice. The workshops were held in conjunction with the WP1 integration meetings that aimed to coordinate the various WP1 activities as well as the relation to the other seven WPs, and to optimize the input in and output of the Delphi study. The WP1 integration sessions were chaired by Rosamund Sutherland. In preparation of the last global survey round (4th round), the results of the previous Delphi rounds were processed in the 3rd STELLAR Delphi round (see Figure 1, p. 9).

3.1 Procedure Overview

The process of the 3rd STELLAR Delphi round in the realm of the STELLAR Delphi study is outlined in Figure 8.

The 3rd STELLAR Delphi round started with an invitation for STELLAR partners to participate in one of two Delphi workshops in Freiburg, Germany; either at the end of July (27th - 28th of July) or at the end of August (24th - 25th of August) 2010. The two Delphi workshops were conducted nearly a month apart. Thus, similar to the survey rounds in a Delphi study, the two Delphi workshops built on each other. The first Delphi workshop focused on the development of *Areas of Tension* based on the results of the previous Delphi round; we discussed Areas of Tension in plenary and group sessions. An Area of Tension describes two opposite positions on a future development within TEL. The description of each position corresponds to a future scenario. These two opposite future scenarios illustrate the tension within a certain area of TEL. With the help of the STELLAR experts' contributions in the first Delphi workshop, we refined the Areas of Tension to be discussed again in the second Delphi workshop. In the second Delphi workshop, we started with the development of the Core Research Areas in a small group of experts. Additionally, we refined the Areas of Tension in a plenary and a small group session, particularly with regard to their finalization for the global survey in the 4th STELLAR Delphi round. More details on the Delphi workshops' procedure is provided in the agenda which can be found in Appendix B.

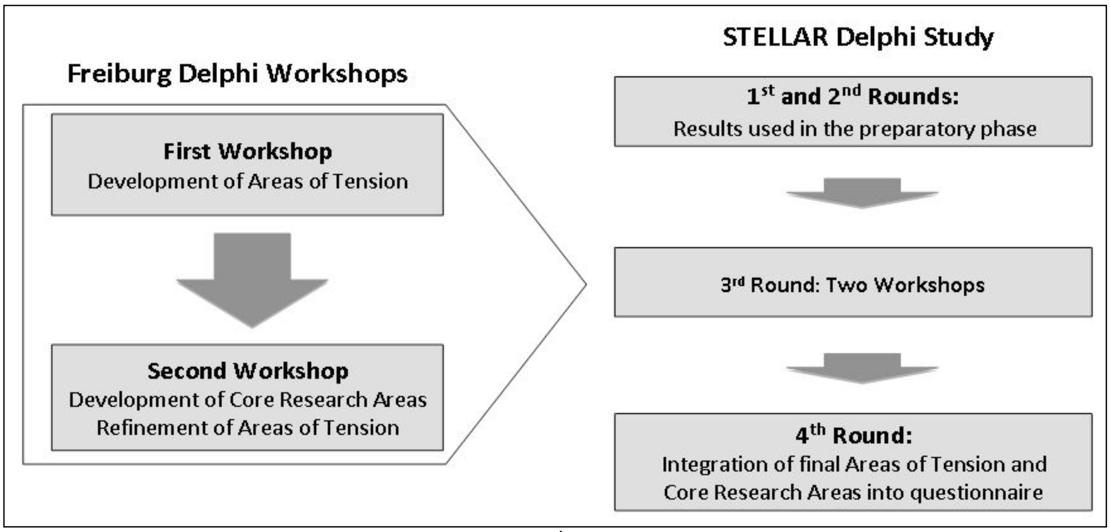

Figure 8. Process of the 3rd STELLAR Delphi round.

The following section refers to the development of Areas of Tension based on the quantitative and qualitative analysis of the Visionary Statements in the 2nd STELLAR Delphi round. The results of the 2nd Delphi round were presented as input for the two Delphi workshops in which we aimed to process Areas of Tension with the help of the STELLAR partners. The development of Core Research Areas started in the second workshop by integrating the rating items of the three questions on Future Trends of the 2nd STELLAR Delphi round. We describe the development of the Core Research Areas in chapter 3.3.

The final Areas of Tension and Core Research Areas are presented in the questionnaire of the 4th STELLAR Delphi round which has started in January 2011.

3.2 Development of Areas of Tension

3.2.1 Preparatory phase of the Delphi workshops

Data analysis of the Visionary Statements of the 2nd STELLAR Delphi round

The results of the Visionary Statements of the 2nd Delphi round, that is the ratings, comments, and the additionally-generated Visionary Statements, were the basis for the development of Areas of Tension (see chapter 2.2.5). In the preparatory phase of the Delphi workshops, the STELLAR Delphi team qualitatively analyzed the set of 375 Visionary Statements which were generated by the global panel of experts in addition to the Visionary Statements presented in the questionnaire. In a first step, five raters independently clustered the statements according to the themes they comprised. This process was inspired by the quantitative results of the 2nd STELLAR

Delphi round, that is, the underlying issues and controversial opinions that emerged in the analysis of the experts' input on the 16 Visionary Statements (see chapter 2.2.4 and 2.2.5). The raters met to discuss and compare their individual clusters and agreed upon a common framework for classification. The clusters of the Visionary Statements confirmed the conflicting positions and visions on the future of TEL found in the quantitative data and revealed supplementary controversial views that further validated the promotion of Areas of Tension for TEL.

One exemplary Area of Tension refers to *personalized learning*. It opposes one position that supports data tracking for personalized learning to another position that emphasizes the importance of data privacy. These positions are implied in the Visionary Statements that were integrated in one cluster. Some exemplary Visionary Statements generated by the panel of experts that also addressed this tension are: "Education will be adaptive to the learners' levels of cognitive and affective characteristics.", "Companies will prescribe employees what to learn and enforce this electronically.", "Policies about what to forget, traces to destroy... (for privacy and better learning) will be established."

The Areas of Tension that derived from this process were discussed in plenary and small group sessions in the Delphi workshops. We prepared them as one-pagers and sent them to the participants of the Delphi workshops in advance. The following four Areas of Tension were discussed in the first Delphi workshop:

- *Mobile, seamless and distance learning – distracted, fragmented, and unreflected learning experience*
- *Digital divide despite technology spread?*
- *Individualized, personalized learning – loss of data privacy*
- *Unlimited access to information – information overload & chaos in the mind*

3.2.2 Implementation of the Delphi workshops

In each Delphi workshop we started with a presentation of the STELLAR Delphi study in general and the design and results of the 2nd STELLAR Delphi round in more detail. Subsequently, we gave an outlook on the 4th STELLAR Delphi round and illustrated the task and goal of the current Delphi workshop.

First Delphi workshop – Development of Areas of Tension

The task and goal of the first Delphi workshop was the further development and discussion of the set of Areas of Tension that derived from the data analysis. We therefore adopted the scenario technique (Albers & Broux, 1999) to stimulate discussion on the Areas of Tension. The experts were encouraged to elaborate on the content of the presented Areas of Tension in small groups.

Based on the steps of the scenario technique described by Albers and Broux (1999), we suggested three steps to animate the discussions on the Areas of Tension:

- Identification of driving forces and relevant indicators
- Development of strategies with the goal of promoting positive developments and preventing negative ones

Following the group session the results were presented and discussed in the plenum. The contributions and advice from the participants were summarized into protocols which we sent to our STELLAR partners as feedback after the Delphi workshop.

Second Delphi workshop – Refinement of Areas of Tension

Although the second Delphi workshop focused mainly on the development of Core Research Areas, we further refined the Areas of Tension with the STELLAR experts. Following a plenary session in which the experts provided general remarks on the Areas of Tension, we went into more detail regarding the questionnaire format of the Areas of Tension to be employed in the survey of the 4th STELLAR Delphi round. In addition to general remarks on the descriptions of the Areas of Tension and proposals for the evaluation format, the experts suggested new Areas of Tension to be added to the existing ones.

3.2.3 Follow-up phase of the Delphi workshops

Final Refinement of the Areas of Tension

As a result of the Delphi workshops we added two new Areas of Tension that emerged from discussions in the second Delphi workshop: *Approved practices vs. continuous innovation in the classroom* and *Individual learning paths vs. standardized learning paths*. Moreover, we merged two existing Areas of Tension (*mobile, seamless and distance learning – distracted, fragmented, and unreflected learning experience* and *unlimited access to information – information overload & chaos in the mind*) because of their overlapping content into one final Area of Tension contrasting *ubiquitous learning opportunities vs. focused and critical processing of information*. The final versions of the five Areas of Tension (presented in detail in chapter 3.4) are:

- data tracking for personalized learning vs. data privacy,
- digital divide despite technology spread,
- ubiquitous learning opportunities vs. focused and critical processing of information,
- approved practices vs. continuous innovation in the classroom,
- individual learning paths vs. standardized learning paths

3.3 Development of Core Research Areas

3.3.1 Preparation of material for the development of Core Research Areas

The second Delphi workshop particularly aimed at receiving input from the STELLAR experts for the development of Core Research Areas. We used the rating items of the three questions on Future Trends of the 2nd STELLAR Delphi round (see chapter 2.2.2 and 2.2.3) as a starting point. A Core Research Area should focus on the Future Trends that were rated to be important/of high impact in the 2nd STELLAR Delphi round. It integrates all three dimensions: societal challenges/demands for TEL, technological developments, and research themes. The Freiburg Delphi team developed two examples of possible Core Research Areas including a title and a short description that served to illustrate the task. The first 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: Computer-Supported Collaborative Learning.

The second exemplary Core Research Area integrated the societal challenge *digital divide (accessibility to digital resources)* and the technological development *technology spread* (cheaper, smaller, easier to use technological tools) that led to the research theme social justice/addressing the digital divide. This Core Research Area was labeled *Fight the digital divide through specific, user-adaptive tools in order to benefit from technology* (see Figure 10).

Example 2

Integration of the three dimensions:

Societal challenge for TEL: Digital divide (accessibility to digital resources)
Technological development: Technology spread (cheaper, smaller, easier to use technological tools)
Research theme: Social justice/addressing the digital divide

Title: Fight the digital divide through specific, user-adaptive tools in order to benefit from technology

Description: Besides delivering access to technological devices and information, an important challenge faced by the field of TEL is enabling those with sparse technology and literacy skills, e.g. disadvantaged people, to benefit from technologies.

One possible solution for this problem might be the development of software and technological tools that are easy to use and adapt to the needs of the users. This might enable more people to capitalize on this technology and can thus be a solution for issues concerning the challenge of social justice.

Figure 10. Exemplary Core Research Area for the second Delphi workshop: Digital Divide.

As a starting point to develop Core Research Areas, we also prepared three lists showing the rating items on future societal challenges and demands, technological developments, and research themes, respectively (see Tables 2-4).

3.3.2 Implementation of the Delphi workshops

Second Delphi workshop – Technique for developing Core Research Areas

During the group session of the second workshop, a group of three experts concentrated on devising Core Research Areas, while another group of experts was working on the refinement of the Areas of Tension (see previous section). A third group of experts discussed the proposal of so called outrageous ideas for TEL research that arose during a plenary session of the WP1 integration part of the workshop.

In the group of experts working on the development of Core Research Areas, the lists on the three dimensions (societal challenges/demands, technological developments, and research themes) facilitated the individual reflection process at the beginning of the group session. After having developed ideas in this individual brainstorming phase, the three experts exchanged and discussed their ideas within the group. Ultimately, they generated a set of Core Research Areas.

3.3.3 Follow-up phase of the Delphi workshops

Development of the final Core Research Areas

After both Delphi workshops were completed, the STELLAR Delphi team developed the final Core Research Areas based on the outcome of the group session in the second Delphi workshop and on the results of the rating items on the Future Trends in the 2nd STELLAR Delphi round.

We developed 11 comprehensive clusters of research themes, referred to as Core Research Areas, oriented on the research themes that were rated most important/most influential in the 2nd Delphi round. For each cluster, we selected societal challenges and technological developments that were related to the research themes. Thus, each cluster of research themes comprised at least one societal challenge and one technological development.

This step in the development of the final Core Research Areas was independently conducted by four members of the Freiburg STELLAR Delphi team. The individual clusters of research themes including the related societal challenges/demands and technological developments were presented and discussed in a team session. We integrated the individual clusters by summarizing similar clusters into a single Core Research Area. Subsequently, we compared our results with the outcome of the group session in the second Delphi workshop and detected a good congruence.

As a next step, we specified the content of the Core Research Areas by adding a short and comprehensive description to each of the 11 Core Research Areas. The descriptions provided a general overview particularly addressing lay people. Furthermore, we intended to complement these descriptions with a few up-to-date research questions for each Core Research Area. For these research questions, we drew on the specific expertise of our STELLAR partners. Again, we prepared an example of the Core Research Area *Computer-Supported Collaborative Learning* including a description and a few research questions. These exemplary research questions were developed by CSCL experts of the Freiburg team. Further, we created a document for each Core Research Area that included the title, the short description, and the items on research themes, societal challenges, and technological developments of the 2nd STELLAR Delphi round that were clustered for this Core Research Area. These documents were sent to the STELLAR members who had attended the Delphi workshops, asking them to develop a few research questions for the Core Research Areas sent to them based on their specific expertise. We received input from nine STELLAR experts; each Core Research Area was elaborated by one to three experts. The experts' input on the Core Research Areas was incorporated in the final Core Research Areas. The final descriptions of the Core Research Areas are presented in the following chapter.

3.4 Final Areas of Tension

The final versions of the Areas of Tension are presented in the order they appear in the questionnaire of the final global survey round (4th Delphi round). The title of each Area of Tension indicates the two opposing positions that illustrate the tension.

3.4.1 Area of Tension 1: Data tracking for personalized learning vs. 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.

3.4.2 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. 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.

3.4.3 Area of Tension 3: Ubiquitous learning opportunities vs. 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 with a virtual lab, speak to a learning partner on the phone, and search for relevant information on the Web and in textbooks. This 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. This enhances biases like the "confirmation bias" (that is 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.

3.4.4 Area of Tension 4: Approved practices vs. 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.

3.4.5 Area of Tension 5: Individual learning paths vs. 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, individualized learning paths can facilitate learning as students are most motivated to deal with subjects they are interested in and feel responsible for. Individualized 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 individualization 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.

3.5 Final Core Research Areas

The 11 final Core Research Areas that are described in the following are (in alphabetical order):

- *Computer-Supported collaborative Learning*
- *Connection between formal and informal learning*
- *Contextualized Learning*
- *Emotional and motivational aspects of learning*
- *Improve practices of formal education*
- *Informal learning*
- *Interoperability*
- *Personalization of learning*
- *Reducing the digital divide*
- *Ubiquitous & mobile technology/learning*
- *Workplace learning*

Each Core Research Area is described by presenting the research themes from which the Core Research Area was derived from and the corresponding societal demands and technological developments.

3.5.1 Computer-supported collaborative learning

The first Core Research Area is called *Computer-Supported Collaborative Learning* corresponding to the research theme *collaborative learning*. A related research theme which was also assigned to this Core Research Area is *social software*. In order to explain what is meant by the Core Research Area *Computer-Supported Collaborative Learning*, we formulated the following description:

“The ongoing evolution of Web 2.0 and the capabilities of modern collaboration and communication tools open up new potentials for *computer-supported collaborative learning (CSCL)*. Distributed learning in groups becomes more and more convenient. CSCL fits squarely into today’s knowledge society, in which knowledge is constantly created and updated, and is increasingly seen as socially constructed. Important technological developments in this research area include social software (e.g. blogs, wikis, and shared objects) and virtual reality.

Research in CSCL aims to understand the learning processes enabled by these technologies, and to develop ways of improving their efficiency by educational and technological measures (e.g. collaboration scripts; automated, adaptive collaboration support). Which cognitive, emotional, and motivational processes on the individual and group level are involved in fruitful learning experiences? And how can we support learners’ collaborative knowledge acquisition and their competence to learn collaboratively?”

3.5.2 Connection between formal and informal learning

The two research themes *connection between formal and informal learning* and *informal learning* led us to the development of the Core Research Area *Connection between formal and informal learning*. This Core Research Area is explained as followed:

"Both formal and informal learning experiences are essential in modern knowledge society. However, transfer between formal learning environments, like school, and informal learning environments, like online communities or museums, are still quite rare. On the one hand, informal learning does not (yet) have a place in many formal settings, even though learners are continuously connected. On the other hand, the transition between formal learning (e.g. university education) and informal learning settings (e.g. the workplace) is often poor.

How can digital technologies be used to support the two-way knowledge exchange between out-of-school learning and in-school learning? In this context, one challenge for TEL-research lies in creating, for example, learning arrangements that link classes with existing online-communities, or make use of the learners' special expertise which they have with regard to their hobbies. Possible future solutions in this area include making personal technology aware of these different contexts, and making artefacts transferable between them. Another particular research challenge concerns the assessment of learners' competences across contexts, and the formal accreditation of competences acquired in informal learning settings."

3.5.3 Contextualized learning

The Core Research Area *Contextualized Learning* refers to the research theme *contextualized learning & context-aware applications*. Contextualized learning is described as follows:

"In principle the contextualization of learning is nothing new, even in formal learning settings (e.g. going on a field trip). However, the development of context-aware applications and tools greatly facilitates supporting and augmenting these kinds of learning experiences. For example, context-aware devices equipped with GPS can serve as location-aware guides in a museum or on a geological excursion, and augment learning by providing additional information via text, voice, or video. In addition, they often enable learners to interact (for example by rating, discussing, or leaving comments). Contextualized forms of learning can thus build bridges between formal and informal learning contexts (e.g. between the classroom and the zoo), and afford collaborative, situated learning experiences.

Important research efforts include issues of improving the effectiveness of contextualized learning arrangements and tools, but also more general questions: In how far does interacting with a smart tool for contextualized learning enhance or disrupt interaction with the real world and with other students? Will situated learning be *additional to* or instead of classroom learning? What are the social and ethical implications of monitoring and supporting learning across settings?"

3.5.4 Emotional and motivational aspects of learning

This Core Research Area shares its name with the corresponding research theme *emotional and motivational aspects of learning.* We introduced this Core Research Area by the following description:

"For several years, research on technology-enhanced learning mainly focused on cognitive aspects. However, research on emotional and motivational factors of technology-enhanced learning is now a growing research area. For instance, both a learner's attitude towards new technologies as well as his or her learning motivation can influence the effectiveness of TEL. In addition, modern technology-enhanced learning arrangements often comprise knowledge building and knowledge creation in collaboration with others.

What motivates people to participate in and contribute to such collaborative processes? How can self-regulation be supported on the group level? For example, many motivational processes can be studied in online communities where people meet informally, and where members have high intrinsic motivation and often own high domain-specific expertise. Further, game-based learning offers interesting new possibilities for enhancing learning motivation and enjoyment. Games and virtual reality have the potential to introduce intrinsic motivation and flow. However, it is a challenge to also achieve these effects in learning tasks where the learners have to elaborate on the material and engage in deep learning."

3.5.5 Improve practices of formal education

The two research themes *improve practices of formal education & formal education systems* and *development of/research on instructional methods & applications* lead to the creation of the Core Research Area *Improve practices of formal education* that is described as follows: "New technological developments offer the potential for innovative and progressive approaches to teaching that have the power to improve practices in formal education. Future TEL-research in this field should enable educators to make the best use of this potential by identifying effective and efficient teaching and learning practices and by developing tools for putting them into practice. Relevant technological developments in this area include computer simulations that enable new forms of inquiry learning and adaptive learning environments that tailor their support to the individual student's needs. However, new technologies do not automatically yield better knowledge acquisition.

Thus, future TEL-research has to explore the potentials and limitations of these technologies and develop guidelines for their implementation. How can new technologies support effective pedagogical methods? How can they help teachers to address school problems such as dropout rates? To ensure effective implementation, research in this area furthermore has to address aspects of teacher education. What forms of professional development best supports teachers to use technology-enhanced learning? How can teachers understand the potential of digital technologies for teaching and learning of particular subject disciplines (e.g. history, mathematics)?"

3.5.6 Informal Learning

We developed the Core Research Area according to the research theme *informal learning* that is described as followed:

"Informal learning refers to the acquisition of skills outside formal educational settings like schools or universities. Informal learning increasingly takes place in technology-enhanced settings, for example, when people communicate with others in an online forum, interact with technology-enhanced artifacts in a museum, use their mobile phone to navigate a map, or search for information on the Internet. There is a large body of evidence for factors promoting or impeding successful formal learning. In comparison, our scientific expertise on informal learning is marginal and has to be enlarged substantially to effectively promote this type of learning without reducing the motivational features of informal settings.

A significant challenge in this area is to examine how learning can be supported without "learning material" and without having to make the learning content explicit beforehand. A meta-topic in this context is the need for the development of evaluation methods, which will enable us to evaluate a learner's progress within real world environments."

3.5.7 Interoperability

The Core Research Area *Interoperability* is named after the research theme *interoperability and the integration of different devices & applications.* What is meant by this Core Research Area is described in the following:

"Efficient usage of novel technological tools, for instance by creating mashups, requires research and developments that improve the interoperability of tools and devices. For example, personalization of learning environments could be facilitated by enabling different learning tools to access and alter a central database of learner characteristics. One important prerequisite to enable interoperability concerns the agreement on a common standard for file formats and protocols (syntactic interoperability). Another important aspect concerns a common information exchange reference model that allows different devices to automatically interpret the exchanged information in meaningful ways (semantic interoperability).

Future research could explore how to define, enforce, and make application profiles that specify contextual requirements without breaking interoperability. Further, it would be worth to identify relevant combinations of technical standards that enable a scalable open learning infrastructure, for example by identifying standards that are still lacking, as well as standards that are no longer relevant. Specific standards for learning technology may be necessary for warranting learning specific requirements or constraints for interoperability."

3.5.8 Personalization of learning

The Core Research Area *Personalization of Learning* originates from the research theme *personalization/individualization of learning (e.g. PLE)*. Two other highly related research themes are *adaptive/Intelligent learning support systems* and *how can we address the needs of all learners*. This Core Research Area is described as followed:

"There are enormous differences between learners that influence how they interact with learning materials and environments. For instance, learners differ in their prior knowledge, their experiences with new technologies, and their learning interests. Ideally, learning environments should be tailored to each individual's specific characteristics. To ensure effective learning and to prevent learners from getting frustrated due to being over- or underchallenged, technology-enhanced learning environments increasingly offer possibilities for adapting and personalizing learning experiences. For instance, they provide error feedback that is tailored to the learner's knowledge level, or enable the learner to customize the learning environment to fit his or her interests.

Research efforts at the frontier of this core area are, for example, directed at the issue of how to move beyond stereotype-based personalization by identifying learning-specific requirements and constraints of personalization. Further research is also needed to develop measures for evaluating the effectiveness of personalization features in learning environments. Another exemplary research questions concerns the distribution of control between learner, teacher, and system."

3.5.9 Reducing the digital divide

The Core Research Area *reducing the digital divide* is named after the research theme *enabling Third World Countries to benefit from technology-enhanced learning*. *Open access to information resources and tools* and *social justice/addressing the digital divide (accessibility to digital resources)* are two additional research themes which are clustered in this Core Research Area. The description that we generated is as follows:

“The digital divide refers to the gap between individuals with access to modern information technology and individuals without such access. The term is most often used to refer to differences between high income and low income countries. However, even within high income societies, there is a digital divide between digitally literate individuals and people without access to technology and/or without the social resources to support the use of such technology. Reducing the digital divide has long been recognized as a major challenge for global politics, as well as for today’s societies. In the future, reducing the digital divide is likely to become an increasingly important goal for TEL-research as well.

Facilitating technology spread is one important research goal in this core area. Furthermore, the development of new technologies that specifically support minorities, less educated people, handicapped people, or elderly people could be a solution. Technology might even open new opportunities to make visible the specific experiences and expertise of less advantaged groups and thus support their participation in the knowledge society. On the other hand, it is also important to explore how the educational system can help to reduce the digital divide, for instance, by providing competencies that are necessary for using the new technologies.”

3.5.10 Ubiquitous & mobile technology/learning

The Core Research Area *Ubiquitous & mobile technology/learning* is named after the research theme *ubiquitous & mobile technology/learning* and is described as follows:

“Portable and mobile technological tools enable learners to access educational content and resources from almost any place and at any time. With the ongoing spread and availability of mobile devices, such as mobile phones or PDAs, learning is increasingly becoming ubiquitous. Ubiquitous learning is closely linked to contextualized learning with regard to the opportunities it offers. However, in contrast to contextualized learning, ubiquitous learning is not necessarily related to the current user context (location, time, etc.). For instance, it is possible to learn vocabulary in the waiting line, read tutorials at the airport, do exercises in the train, or plan group work in a restaurant. These examples already emphasize that mobile devices can particularly facilitate knowledge acquisition in informal learning settings; however, they can also be helpful to connect formal and informal education.

Research is needed to better understand the impact of mobile technologies and the ubiquitous availability of informational and learning resources on students’ learning practices. For example: How is it possible to empower learners to use ubiquitous technology and information in a meaningful way? How can ubiquitous technologies be designed to provide active support for learning? How can a smooth flow of learning across devices and locations be enabled?”

3.5.11 Workplace learning

This Core Research Area is named *Workplace Learning* after the research theme *lifelong learning & workplace learning*. Workplace learning is depicted as:

“The development from an industrial to a knowledge society has brought about far-reaching job market changes and new requirements for lifelong learning. In particular, today’s work practices require a constant update of work-related knowledge and the acquisition of new skills. Knowledge and skill acquisition increasingly take place on demand in a workplace.

In order to support workplace learning in the future, it will be crucial to identify the user’s knowledge based on the evidence that can be captured about him or her. Being able to analyze data from different sources with respect to a learner’s current activities and his or her competences will be a crucial challenge. Another challenge will be to deal with real-world contexts in which learning will increasingly take place in working life. Technology (e.g. recommender and adaptable systems) needs to act as a scaffold that recognizes the strong need for self-direction in learning, but also offers support to learners. Further, innovative interaction paradigms and interfaces should allow learners to utilize the full power of recommendations/adaptation also in their mobile environment. Finally, the connection between the individual and the organizational perspectives is a significant challenge.”

4 Outlook

4.1 Dissemination and Impact of the STELLAR Delphi Study

The findings that we present in this report have been spread not only within the STELLAR network for interlinkage between and use in the different STELLAR instruments, but have also been spread among researchers and stakeholders outside the STELLAR network.

In the first virtual Meeting of Minds (WP2), the members of the Strategic Advisory Board discussed the Areas of Tension and shared their expertise and evaluation on the presented tensions in TEL and TEL research. The proposed Areas of Tension were very well received by these experts and their comments helped us to put the finishing touches on the Areas of Tension. In order to literally spread the word about the STELLAR Delphi study, we are working on a podcast (WP 2) about the STELLAR Delphi study that will focus on the results presented in this report. This podcast will be featured in the STELLAR podcast series on TELeurope and the STELLAR Delphi webpage.

Apart from the dissemination of the results via STELLAR instruments, STELLAR partners have already presented and plan to present these results at conferences and workshop to multiple audiences, such as graduate students, senior researchers, and stakeholders.

When the STELLAR Delphi study started, stellarnet.eu was the webpage we used to present information to a broad audience on the web. Now that TELeurope.eu (WP5) has been launched with its new design, we plan to move the "STELLAR Delphi"-page to TELeurope and thereby hope to draw even more attention towards both towards TELeurope and the STELLAR Delphi study.

Apart from its main goal, that is to envision the future of TEL research, the STELLAR Delphi study increases the visibility of STELLAR and the networks' work to important stakeholders. When we sent out the invitations to more than 1500 experts around the globe to participate in the STELLAR Delphi study (4^{th} STELLAR Delphi round), they were informed about the STELLAR network, its purpose, and the preliminary results of the first three STELLAR Delphi rounds. Additionally, we attached the first STELLAR Delphi briefing (see Appendix C) which was particularly designed to give a snapshot of the most important aspects of the STELLAR Delphi study and was branded with the TELeurope logo.

4.2 The 4th STELLAR Delphi Round

The 4th STELLAR Delphi round is the final global survey round. This round serves to evaluate the revealed Areas of Tension within TEL and to prioritize and elaborate the identified Core Research Areas for TEL research.

In January 2011, we invited more than 1500 experts from around the globe to participate in the survey. The invited panel of experts consisted of all the experts that were nominated for the first global survey round (2nd Delphi round), new personal nominations by STELLAR partners, and Program Committee members of additional TEL-related conferences. In the recruiting process for the global panel of experts, we again asked the STELLAR partners for expert nominations in December 2010. We especially requested the STELLAR partners to nominate experts from countries that had been underrepresented in the first global survey, for example eastern European countries. Supplementary to the new personal nominations, we also nominated the members of Program Committees of renowned TEL-related conferences for the global panel of experts.

In the survey, we have asked the experts to assess the relevance of the five Areas of Tension for TEL and TEL research and to prioritize the 11 Core Research Areas. Currently, the data collection of the 4th Delphi round is still under way.

4.3 The 5th STELLAR Delphi Round

In the last STELLAR Delphi round, we aim to discuss and disseminate the results of the entire STELLAR Delphi study within the whole STELLAR network and beyond. To do so, we will organize workshops similar to the 3rd STELLAR Delphi round and process the results into executive briefings for policy-makers. In discussing the results with STELLAR partners, we will also focus on incorporating them into the findings of other STELLAR instruments such as the virtual meeting of minds. We plan to invite more STELLAR members to the workshops compared to the rather restricted panel in the 3rd STELLAR Delphi round. Furthermore, it would be interesting to discuss the results with practitioners in different TEL-related areas such as teachers or lawyers. The involvement of most of the STELLAR researchers as well as practitioners from outside the STELLAR network could promote the acceptance of common research goals in the future of TEL. The main objective of this last STELLAR Delphi round should be a better connection between future societal demands and technological developments in the field of TEL and a mutual agreement upon corresponding research needs for the future of TEL.

To sum up, the completion of the 5th STELLAR Delphi round and the entire STELLAR Delphi study will contribute to the overarching objective of the STELLAR network, that is, the formulation of recommendations for future TEL-research programs.

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6 Appendix

A 2nd STELLAR Delphi Round – Global Panel of Experts

- Aehnelt, Mario
- Ainley, Janet
- Akbari, Mostafa
- Allert, Heidrun
- Al-Zoubi, Abdullah
- Angelova, Galja
- Arnedillo-Sánchez, Inmaculada
- Arruarte, Ana
- Atkinson, Rober
- Auer, Michael E.
- Avouris, Nikos
- Azevedo, Roger
- Bailey, Paul
- Baker, Michael
- Baker, Ryan
- Barzel, Bärbel
- Beishuizen, Jos
- Bente, Gary
- Berthold, Kirsten
- Betrancourt, Mireille
- Bielikova, Maria
- Blascovich, James
- Bourdeau, Jacqueline
- Bredeweg, Bert
- Bredl, Klaus
- Brna, Paul
- Bromme, Rainer
- Bruillard, Eric
- Cartelli, Antonio
- Cater, Ki
- Catrambone, Richard
- Chang, Ben
- Charlier, Bernadette
- Chen, Wenli
- Clark-Wilson, Alison
- Conati, Cristina
- Cook, John
- Cornu, Bernard
- Cranmer, Sue
- Demetriadis, Stavros
- Dennett, Christopher
- Desmarais, Michel
- Dettori, Giuliana
- Devine, Jim
- Di Eugenio, Barbara
- Dimitriadis, Yannis
- Dirckinck-Holmfeld, Lone
- Dolog, Peter
- Douch, Rebecca
- Drysdale, Ruth
- Du Boulay, Benedict
- Eagle, Sarah
- Ebner, Martin
- Euler, Dieter
- Faatz, Andreas
- Facer, Keri
- Falconer, Liz
- Ferri, Paolo

- Fischer, Gerhard
- Forbes, Andrea
- Franzolini, Pablo
- Frutos-Perez, Manuel
- Funke, Joachim
- Gall, Marina
- Garlatti, Serge
- Gjedde, Lisa
- Grandbastien, Monique
- Granger, Sylvianne
- Grant, Lyndsay
- Greenfield, Adam
- Grell, Petra
- Haenggi, Brigitte
- Häkkinen, Päivi
- Hall, Richard
- Hansen, Miriam
- Harrer, Andreas
- Harrison, Bob
- Haseloff, Anikar M.
- Heo, Heeok
- Herbolich, Jim
- Herrmann, Thomas
- Hilzensauer, Wolf
- Hiom, Deborah
- Hmelo-Silver, Cindy
- Hoadley, Christopher
- Hodgins, Wayne
- Hodson, Simon
- Holmes, Brian
- Hoppe, Ulrich
- Howard-Jones, Paul
- Hughes, Malcolm
- Huxley, Lesley
- Igel, Christoph
- Järvelä, Sanna
- Jay, Tim
- Kafai, Yasmin
- Karacapilidis, Nikos
- Kay, Judy
- Kerawalla, Lucinda
- Kernohan, David
- Kickmeier-Rust, Michael D.
- Kirkland, Kieron
- Kirschner, Paul
- Kirsh, David
- Kloos, Carlos Delgado
- Kluge, Anders
- Knight, Sarah
- Kramer, Mark
- Krämer, Nicole
- Krüger, Marc
- Kukulska Hulme, Agnes
- Kwok, Lam-For
- Kyza, Eleni
- Labat, Jean-Marc
- Lau, Lydia
- Laurillard, Diana
- Lazonder, Ard
- Leeson, Jerry
- Lingnau, Andreas
- Littig, Peter
- Liu, Chao-Lin
- Ludvigsen, Sten
- Luengo, Vanda
- Lund, Kristine
- Martin, Christian
- Martínez-Mones, Alejandra
- Matsuba, Ryuichi
- Mavrikis, Manolis

- Mazza, Riccardo
- McNaught, Carmel
- Metcalf, David
- Milrad, Marcelo
- Mitrovic, Tanja
- Morales, Raphael
- Muramatsu, Brandon
- Nanopoulos, Alexandros
- Nicaud, Jean-François
- Niegemann, Helmut
- Noss, Richard
- Nückles, Matthias
- Nyengaard, Lars
- Ochoa, Xavier
- Ogata, Hiroaki
- Orton, Jenny
- Paas, Fred
- Pachler, Norbert
- Paiva, Ana
- Panke, Stefanie
- Pannese, Lucia
- Parsons, David
- Pata, Kai
- Pemberton, Lyn
- Peraya, Daniel
- Pérez-Marín, Diana
- Perrotta, Carlo
- Petrides, Lisa
- Pierroux, Palmyre
- Pilkington, Rachel
- Place, Emma
- Plugge, Leo
- Porayska-Pomsta, Kaska
- Prenzel, Manfred
- Putland, Gary
- Quintana, Chris
- Raffier, Mido
- Raggi, Emidio
- Ravenscroft, Andrew
- Rebolledo Mendez, Genaro
- Reimann, Peter
- Renkl, Alexander
- Riss, Uwe
- Ritter, Steve
- Robes, Jochen
- Roll, Ido
- Romano, Daniela
- Rose, Carolyn
- Saliah-Hassane, Hamadou
- Sancho, Juana
- Sandford, Richard
- Savin-Baden, Maggi
- Schaffert, Sandra
- Schiefner, Mandy
- Schneider, Daniel
- Schwartz, Daniel
- Seufert, Tina
- Sloep, Peter
- Slotta, Jim
- Stahl, Gerry
- Steffens, Karl
- Tardini, Stefano
- Tarrant, Tim
- Tatar, Deborah
- Thalmann, Stephan
- Thillosen, Anne
- Trausan-Matu, Stefan
- Traxler, John
- Tredgold, Jasper
- Triggs, Pat

- Turcsanyi-Szabo, Marta
- Ulloa, Antonio
- Ullrich, Carsten
- Urban, Bodo
- Valcke, Martin
- van Gog, Tamara
- van Joolingen, Wouter
- VanKeer, Hilde
- Vanlabeke, Nicolas
- Vicari, Rosa
- Weibelzahl, Stephan
- Weinberger, Armin
- Wilkesmann, Uwe
- Williamson, Ben
- Williamson, Heather
- Wolpers, Martin
- Wuttke, Dieter
- Yamada, Tsyuneo
- Yoo, Jaetaek
- Zacharia, Zacharias
- Zhang, BaoHui
- Zimmermann, Volker
- Zorman, Mirko

B Agendas of the Delphi Workshops

First STELLAR-Workshop in Freiburg (27th – 28th July)

Institute of Psychology, Department Cognition, Emotion, and Communication

<u>Tuesday July 27th at 2 pm – 6.30 pm</u>

12.00 pm: (optional) Lunch at a restaurant for participants arriving earlier (meeting point: Institute of Psychology)

1.30 pm: Welcome coffee and tea at the Institute of Psychology

2 pm – 2.15 pm: Official welcome and introduction (Ros and Hans)

2.15 pm – 4 pm: WP1-Integration (planned and chaired by Ros)

4 pm – 4.30 pm: Coffee break

4.30 pm – 5.30 pm: Presentation of the STELLAR Delphi study: results of the 2nd STELLAR Delphi round and outlook on the 4th STELLAR Delphi round (Freiburg STELLAR-Delphi-team)

5:30 pm – 6.30 pm: Delphi: Discussion of results and development of Areas of Tension (Freiburg STELLAR-Delphi-team)

8 pm: Dinner (Restaurant Oberkirch**,** Münsterplatz 22, Freiburg)

<u>Wednesday July 28th at 9 am – 3 pm</u>

9 am – 11 am: Delphi: Discussion of results and development of Areas of Tension (Freiburg STELLAR-Delphi-team)

11 am – 11.30 am: Coffee break

11.30 am – 12.30 pm: WP1-Integration (planned and chaired by Ros)

12.30 pm – 1.30 pm: Lunch break

1.30 pm – 2.30 pm: WP1-Integration (planned and chaired by Ros)

2.30 pm – 3 pm: Wrap-up (Ros and Hans)

List of participants

Denis Gillet	Ecole Polytechnique Fédérale de Lausanne (EPFL)
Frank Fischer	Ludwig-Maximilians- Universität München (LMU)
Fridolin Wild	Knowledge Media Institute of the Open University (OPUK)
Marcus Specht	Open Universiteit Nederlands (OPNL)
Nicolas Balacheff	CNRS-Université Joseph Fourier (UJF)
Ros Sutherland	University of Bristol (UB)
Ulrike Cress	Knowledege Media Research Center (KMRC)

Members of the Freiburg STELLAR-Delphi-team:

Hans Spada, Anne Deiglmayr, Dejana Diziol, Malte Jansen, Christine Plesch, Celia Kaendler, Berit Lindau, Sebastian Kuebler

Second STELLAR-Workshop in Freiburg (24th – 25th August)

Institute of Psychology, Department Cognition, Emotion, and Communication

Tuesday August 24th at 2 pm – 6.30 pm

1.00 pm: Welcome coffee and tea at the Institute of Psychology

2 pm – 2.15 pm: Official welcome and introduction (Ros and Hans)

2.15 pm – 4 pm: WP1-Integration (chaired by Ros)

4 pm – 4.30 pm: Coffee break

4.30 pm – 5.30 pm: Presentation of the STELLAR Delphi study: Results of the 2nd STELLAR Delphi round, method and procedure of the 3rd STELLAR Delphi round and outlook on the 4th STELLAR Delphi round (chaired by the Freiburg STELLAR-Delphi-team)

5:30 pm – 6.30 pm: Delphi: Discussion and evaluation of refined Areas of Tension (chaired by the Freiburg STELLAR-Delphi-team)

7.30 pm: Dinner (Restaurant Oberkirch**,** Münsterplatz 22, Freiburg)

Wednesday August 25th at 9 am – 3 pm

9 am – 11.00 am: Delphi: Development of Research Core Areas in plenum and small groups (chaired by the Freiburg STELLAR-Delphi-team)

11.00 am – 11.30 am: Coffee break

11.30 am – 12.30 pm: WP1-Integration (chaired by Ros)

12.30 pm – 1.15 pm: Lunch break

1.15 pm – 2.15 pm: WP1-Integration (chaired by Ros)

2.15 pm – 2.45 pm: Wrap-up (Ros and Hans)

List of participants

Eelco Herder	Research Center L3S Hannover (LUH)
Erik Duval	Hoogleraar, K.U. Leuven (KUL)
Mike Sharples	University of Nottingham (UNOTT)
Paul Lefrere	Knowledge Media Institute of the Open University Milton Keynes (UKOU)
Pierre Dillenbourg	Ecole Polytechnique Fédérale de Lausanne (EPFL)
Ros Sutherland	University of Bristol (UB)
Tobias Ley	Know Center Graz (KC)

Members of the Freiburg STELLAR-Delphi-team:

Hans Spada, Nikol Rummel, Dejana Diziol, Christine Plesch, Celia Kaendler, Sebastian Kuebler, Kristin Reiße

C STELLAR Delphi Study Briefing

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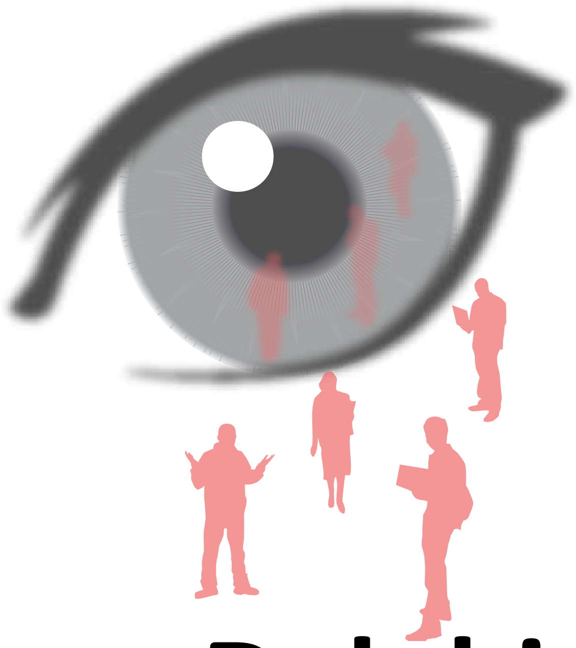


STELLARNET Briefing #2
January 2011

Delphi Study : Emerging findings

The STELLARNET Delphi study identifies the most relevant research issues and trends in technology-enhanced learning (TEL) and TEL research.

Looking into the future

The future of TEL and TEL research will be shaped by developments in technology, societal challenges and advances in pedagogy. Experts suggest that education systems need to respond to societal challenges and highlight promising advances in technology that are likely to impact on learning.

Research is needed to understand trends in learning in schools, colleges, universities and workplaces and how informal learning fits with formal learning. Technology enables increasing personalisation of learning, which is taking place in a wide range of contexts using a range of different devices; one of the challenges is to find ways to ensure interoperability between all these devices.

Tensions

New ways of learning, as identified by experts, challenge established and well understood traditions of learning and teaching in educational institutions, in the workplace and at home.

The STELLARNET Delphi study aims to:

- envision key research themes related to TEL in terms of developments in technology, education, and societal challenges;
- explore goals and visions of TEL experts;
- integrate these perspectives in a common framework for future European TEL research.

__STELLARNET__ aims to bring together the different disciplines in __TEL__ and to develop a strategic research agenda for __TEL__ by drawing on the views the widest range of disciplines. One way __STELLARNET__ is doing this is through the __Delphi study__.

Study design

In general, Delphi studies aim to identify emerging trends and future developments in a given field. The STELLARNET Delphi study began in 2009 and is composed of five rounds (three internal and two external). In the internal rounds the results of the external rounds are analysed, generalised and transferred into materials to be processed and evaluated by the survey participants in subsequent rounds.

The STELLARNET Delphi study
This briefing reports on work-in-progress following the completion of the 2nd round carried out from February to late April 2010. 230 global experts in Technology-Enhanced Learning (TEL) participated by responding to a questionnaire based on the results of the first Delphi round (internal).
Experts evaluated the importance of future societal and educational demands and challenges, the impact of technological developments, and the importance of future research themes. They also rated visionary statements for their desirability and likelihood of becoming reality by 2025. This briefing draws on the work of the 3rd round (an internal round) which drew together the results of the 2nd round.

Main findings (1): Core research areas

The experts identified eleven core areas for future TEL research.

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.

Main findings (2): Areas of tension

Five Areas of Tension present opposing views on future developments in TEL.

Data tracking for personalised learning versus data privacy: Keeping track of a learner's data enables the personalisation of learning environments but this could lead to misuse of personal data, such as a person's learning history.
Digital divide despite technology spread: Digital technologies are becoming smaller, cheaper and easier to operate but the difference between the "haves" and "have-nots" is not decreasing.
Ubiquitous learning opportunities versus focused and critical processing of information: Modern mobile and portable devices enable ubiquitous information access and thus ubiquitous learning opportunities but there is also a need for essential skills to identify and focus on relevant aspects, to search information and test hypotheses, and to elaborate on learning content.
Established practices versus continuous innovation in the classroom: Technology-enhanced learning in the classroom should create and support reliable, well established and highly successful school practices but on the other hand new technological tools should be employed in real-world classrooms as early as possible.
Individual learning paths versus standardised learning paths: Within the changing educational landscape an infinite number of individual learning profiles are possible but this could lead to a loss of standardisation needed for assessment, accreditation and for mutually shared knowledge within a society.

What the experts said

Some of the remarks made by experts illustrate the findings.

Digital Divide
"Learners are not homogeneous and all exist on one side or the other of multiple digital divides, furthermore new technologies create new digital divides."
"But...beware of second digital divide, if quality of use is not a focus. We need a firm purpose to achieve universal digital fluency."

Personalisation
"By 2025 learning we will see the mass personalisation of learning through deep degrees of context awareness, recommendation technology and other means that will result in "just right" learning that is matched to the individual person, moment and context."

Ubiquitous vs. critical processing
"It would be undesirable to use TEL to diminish important thinking skills carried out by learners. There is probably a fine line between using TEL to free up cognitive resources in order to concentrate on more interesting questions and using TEL to perform tasks that learners should be performing themselves."

Individual learning paths
"Personal learning trajectories appear a good idea and it is likely some experimentation will occur, but issues of formalising qualifications, monitoring and designing systems that are automated enough to make this a realistic prospect in comparison with more formal teaching methods, except in certain disciplines and at certain levels, are so complex for underlying technology that large scale rollout as a general method of education is very unlikely in such a small space of time."

2nd STELLARNET Delphi Round
Country Distribution – Worldwide and Europe

Most of the European countries, America, Asia and Australia were represented in this first global survey.

Outlook

The 4th STELLARNET Delphi round will start in January 2011 surveying again a global panel of experts. The underlying issues and relevant trends for future TEL research will be further explored by presenting the identified Core Research Areas and Areas of Tension. The experts will assess the relevance of the Areas of Tension for future research, rate the importance of the Core Research Areas and provide first ideas for corresponding research themes. The experts' input in this final survey round is crucial to the successful completion of the STELLARNET Delphi study, which will help shape evidence-based recommendations for future TEL research themes that can inform funding agencies concerning their investments in TEL and future TEL research.

The open network of excellence in technology enhanced learning

STELLARNET is a multidisciplinary consortium that brings together researchers from psychology, education, cognitive science, computer science, human factors, organisational and management science. Its overall aim is to focus on advances in technology enhanced learning that engage learners and teachers in new ways of learning, radically changing both what it means to learn and what it is possible to learn.

The emphasis is on both adapting learning to local cultural and personal situations and transforming learning into permanent and valuable knowledge assets. An important focus is the shift from learning as a focused, individual activity to lifelong learning that is interwoven in our daily activities and that involves collaborative knowledge sharing and building. This type of learning has become commonplace, but is not yet sufficiently understood and supported by technology – most current learning management systems are based on individual, formal learning.

Key references for this briefing

STELLARNET D1.3: First Delphi Study Report

Further deliverables are available at http://bit.ly/aukWxX

Kaendler, C., Plesch, C., Deiglmayr, A., Diziol, D., Rummel, N., & Spada, H. (submitted). Emerging tensions in the future of technology-enhanced learning: First results of an international Delphi study. In Miyake, N. Spada, H., & Stahl, G., (Eds.) (2011). Connecting computer-supported collaborative learning to policy and practice – CSCL 2011 Conference Proceedings.

Plesch, C., Jansen, M., Deiglmayr, A., Rummel, N. Spada, H., Heinze, N., & Cress, U. Opinions on future research themes for technology-enhanced learning (TEL): A Delphi study. In S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Rowe, G., & Wright, G. (1999). The Delphi technique as a forecasting tool: issues and analysis. Journal of Forecasting, 15(4), 353-375.

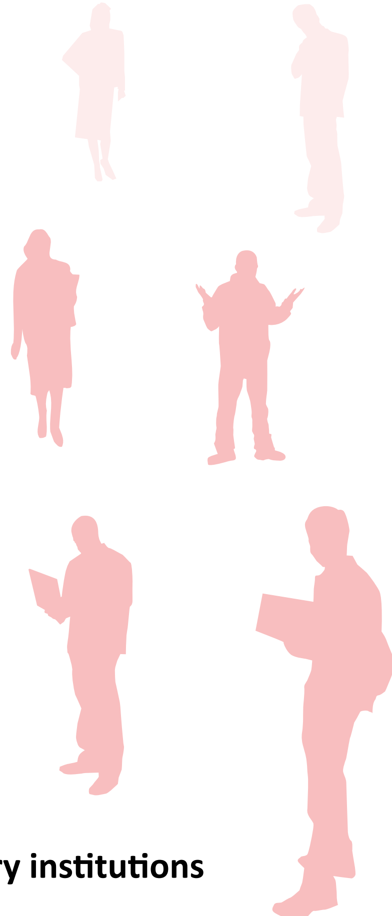
STELLARNET unites the disjoint scientific communities with a virtual and distributed centre of excellence that expands the capacity of each research unit and that fits the challenges for the future of TEL.

STELLARNET connects with policy-makers to provide a strategic direction for the integration of TEL excellence to 2012 using a framework that explicitly relates to improving learning and educational systems.

STELLARNET reduces discipline fragmentation by promoting the integration of key European research teams through collaborative projects, research exchanges, sharing of tools, models, concepts, methods and agendas.

STELLARNET reduces community fragmentation by bringing together the key stakeholders in European TEL and stimulate ongoing knowledge exchange between them.

STELLARNET looks beyond the Network partnership and actively solicits the exchange of views, knowledge, feedback and visions of key stakeholders in TEL: researchers, developers, end-users both in education and in industry.



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University of Nottingham, Nottingham, UK
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Knowledge Media Research Center, Tüebingen, Germany
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SEVENTH FRAMEWORK PROGRAMME

European Commission
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