Emerging Tensions in the Future of Technology-Enhanced Learning: First Results of an International Delphi Study

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Abstract: In this paper, we present results of an international Delphi study on technology-enhanced learning (TEL). The 5-round Delphi study is carried out as part of the European Network of Excellence STELLAR. This article focuses on the results of the 2nd Delphi round, in which 230 global experts in the field of TEL evaluated, as part of a more extensive questionnaire, visionary statements on TEL that had been identified in the previous round. Experts rated each statement's desirability as well as its likeliness to become reality by 2025. Statistical analyses yielded seven types of visionary statements and revealed possible areas of tension within TEL and TEL research in the future. To conclude this article, we lay out the implications of the results and give an outlook on the next rounds of the STELLAR Delphi study.

Introduction

The prevalence and the capabilities of *information and communication technologies* (ICT) in educational settings have sparked the interest of researchers in technology-enhanced learning (TEL) in last decades. In the past, forecasting the future of TEL has been in the focus of several studies such as the annual Horizon Report by the New Media Consortium (2010). The present study particularly aims at identifying trends and visions for TEL in order to create a catalogue of recommendations for future TEL research. We employed the Delphi method that allows for surveying a large panel of experts to identify emerging trends and future developments in a given field (Linstone & Turoff, 1975; Rowe & Wright, 1999). In general, Delphi studies involve several rounds of surveys among experts that build on each other. The results of each round are analyzed and transferred into materials to be processed and evaluated by the survey participants in the subsequent rounds.

The Delphi study presented in this paper is embedded in the European Network of Excellence STELLAR (**S**ustaining **T**echnology **E**nhanced **L**earning **LA**rge-scale multidisciplinary **R**esearch, http://www.stellarnet.eu/program). The STELLAR Delphi study is composed of five rounds; two large global survey-rounds among TEL experts from outside the STELLAR network and three rounds that are conducted within the STELLAR network. In the 1st Delphi round, experts generated future trends in TEL research and visionary statements on future developments in TEL (Plesch et al., 2010). This paper focuses on the 2nd Delphi round, that is, the first of two global expert survey-rounds in which the results of the 1st Delphi round were discussed and evaluated. More specifically, we examine the experts' ratings of visionary statements for TEL concerning the likeliness that these will become reality, and how desirable this would be. The combined analysis of the ratings on both scales for each statement revealed specific patterns in the expert answers. While some statements were perceived as either little or very realistic/desirable by most of the experts, other statements yielded heterogeneous ratings, in other words, people disagreed on the likelihood and desirability of these visions to come true. The mixed patterns suggest tensions inherent in these visions. In addition, we analyzed the experts' comments on the visionary statements that either confirmed the ratings or revealed additional tensions that were not visible from the overall ratings. The identification of tensions in TEL can encourage future research, boost new technological developments, and provide further insights in recurrent TEL-related debates within the research community and the society.
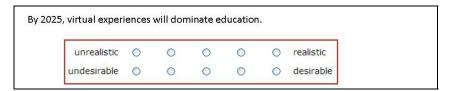
Method

We asked 511 experts in the field of TEL (researchers, developers, policy-makers, practitioners, and business people) to participate in the 2nd Delphi round. Expert status was based either on nomination by one of the STELLAR partners or on membership in the program committee of TEL-related conferences. Out of the 230 global experts who answered the survey, 172 worked in European countries, 52 experts worked outside Europe (Asia, North and South America, Australia), and six experts did not provide information about the country they worked in.

The experts answered an online questionnaire that encompassed closed- and open-ended items: closed-ended rating items on future trends and visions in TEL and TEL research and open-ended items for comments, feedback, as well as personal opinions. This paper concentrates on the closed-ended questions that incorporated

a selection of visionary statements identified in the 1st Delphi round (Plesch et al., 2010). The data collection and analysis took place from February to May 2010.

Figure 1 illustrates the format of the visionary statements used in the 2nd Delphi round. A visionary statement portrays a fraction of a future scenario within the time frame of 15 years. The evaluation of the visionary statements by the experts is employed to identify visions and trends for the future of TEL. The selection of visionary statements used in the 2nd Delphi round was based on statements generated by STELLAR members in the 1st Delphi round. Out of the 134 visionary statements produced by the panelists in the 1st Delphi round, we identified a sample of 16 visionary statements (see Table 1) that included those visions that had been mentioned by several experts and that covered the most important future trends in TEL that other parts of the 1st Delphi survey had identified (Plesch et al., 2010). The experts rated the likeliness of the statement to become reality within the next 15 years and the desirability for each of the 16 visionary statements on a 5-point Likert scale ranging from *unrealistic* (1) to *realistic* (5) and from *undesirable* (1) to *desirable* (5) (see Figure 1).
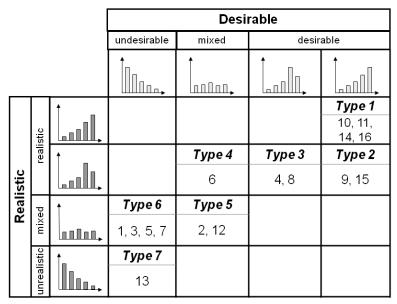

Figure 1. Questionnaire of the 2nd STELLAR Delphi Round – Format of the Visionary Statements.

Data Analysis

In analyzing experts' responses to the 16 selected visionary statements, we first of all 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 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 qualitatively analyzed for additional information indicating tensions in TEL.

A repeated-measure ANOVA revealed that the expert ratings of the 16 visionary statements varied significantly for the different statements; realistic-rating items: $F(1, 14.01) = 62.97$, $p < .001$, $f = .55$ and desirability-rating items: $F(1, 13.37) = 199.08$, $p < .001$, $f = .99$. The descriptive parameters median, skewness, mean, and standard deviation (see Table 1) further illustrate the differences between the rating-items. The median score is the value that separates the upper and lower half of the sample. 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 within the experts' ratings on the two rating dimensions *realistic* and *desirability* across the 16 statements.

Visionary Statements – Types Resulting from the Distribution Patterns.

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 3.0, over 3.0, or smaller than 3.0, and a skewness score of 0, larger than 0, or smaller 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 2 illustrates the 16 possible types of frequency distributions that result from the combination of the two dimensions. In our data, only seven types were detected (for the classification of the visionary statements, see Figure 2). While the ratings for types 1, 2, 3, and 7 were quite homogenous, indicating high agreement amongst experts, the mixed patterns in the types 4, 5, and 6 suggest emerging tensions in TEL. For the purpose of this paper, we therefore particularly concentrate on the latter and merely summarize the homogenous types.

Table 1: 16 visionary statements (MD denotes median, V skewness, M mean, SD standard deviation).

Item	Questionnaire Items of the 2nd Delphi Round	Scale	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

Results

Emerging Tensions (Type 4, 5, and 6; VS 1, 2, 3, 5, 6, 7, and 12)

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. The disagreement in the ratings points towards emerging tensions in TEL.

For the statement classified as type 4 (realistic and mixed desirable), experts agreed that the development would quite certainly become reality in the future, but did not agree on whether its consequences would be desirable or not. 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 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.

For two of the statements, experts did neither agree in their desirability ratings nor in their realistic ratings (type 5 – mixed realistic/desirable). 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 distributed among all options almost evenly. The experts' comments provided insights in the reasons for their ratings. For example, one expert pointed 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 processes might compromise the implementation of personalized learning trajectories; the adoption of new digital tools for learning into the classroom to enable new methods of learning such as personalized or computer-supported collaborative learning may have both positive and negative consequences for formal education.

For several statements experts agreed that they described undesirable trends; however, there was no consensus as to how realistic these undesirable trends were (type 6 – mixed realistic and undesirable). Visionary statement 5 ("By 2025, no content needs to be memorized because wearable context-aware devices will provide the relevant information") animated the experts to think about which skills and abilities learners will have to master and which skills will be offloaded to a technological tool. The statement suggests that technology will be incorporated in everyday objects and will help the learner to receive tailored information about his/her surroundings. The experts differed in their evaluation of how likely this trend would become reality in the future. Further analysis of the experts' comments revealed the low ratings on the desirability dimension to be due to the importance of prior knowledge for learning. In summary, both the results of the ratings as well as the additional comments point towards a tension in TEL: the role of ubiquitous, mobile learning in the light of the acquisition of complex thinking skills and reflected learning experiences.

Homogeneous Trends (Type 1, 2, 3, and 7; VS 4, 8, 9, 10, 11, 13, 14, 15, and 16)

The statements that fall under types 1, 2, 3, and 7 show clear trends in the expert answers considering the quantitative results. Two statements were considered to be both very realistic and very desirable by most experts (type 1). One statement concerns 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). The second 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 (Plesch et al., 2010): "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 an outstanding characteristic: this statement was rated as most desirable with 80.5 % of the experts providing the highest rating score possible (5).

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.

For example, the experts agreed on 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"). Another statement that was rated as both realistic and desirable deals 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").

In summary, experts were 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, and an expected increase in social justice due to the increasing availability of TEL tools. There was only one statement that was judged to be both unrealistic and undesirable (type 7): "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.

Despite the experts' agreement concerning the visionary statements of type 1, 2, 3, and 7, the analysis of the qualitative data, that is, the comments on the visionary statements, 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 (see above). 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."

Discussion and Outlook

The presented results of the 2nd Delphi round uncover conflicting positions and opinions held by experts in the field of TEL. 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 analysis of the qualitative data, that is, the comments on the visionary statements, uncovered further issues that indicated underlying tensions.

We elaborated these issues and defined five *Areas of Tension* all of which present two opposing views on a future development in TEL. The first Area of Tension opposes the personalization of learning through data tracking to the related data privacy issues. The second Area of Tension opposes individualized learning paths to standardized learning paths, taking into account the issues of accreditation and assessment. In the third Area of Tension the disadvantages and advantages of introducing innovative technology into the classroom at an early stage are weighed against the reliance on approved practices. The fourth Area of Tension contrasts ubiquitous learning opportunities from focused and critical processing of information. The last Area of Tension raises the question whether the observed technology spread will really help to overcome the digital divide in the future. The identified *Areas of Tension* were refined and extended in the realm of two workshops held with STELLAR partners in summer 2010. In a second global Delphi round, we aim to further explore the underlying issues for future TEL research by presenting the identified Areas of Tension as part of a more extensive survey. The results and conclusions of the STELLAR Delphi study concerning the Areas of Tension will promote the comprehension of the tensions which will play an important role in the future of TEL.

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