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Empirical experiment of comparing traversed hyperlinks with conceptual relationships in concept maps

(corresponding to analysis in Subchapter 9.3 of Lauri Lahti's doctoral dissertation "Computer-assisted learning based on cumulative vocabularies, conceptual networks and Wikipedia linkage" (Lahti 2015a) and (Lahti 2015b, Appendixes K, N, R, and T))

To verify the suggested pedagogic value of knowledge acquisition with the proposed method we gathered an extensive *collection of concept maps* drawn by 103 students describing their flow of association covering diverse pedagogic topics and containing 1827 conceptual relationships and compared them to corresponding *automated exploration patterns* in learning concept networks containing 1601 conceptual relationships generated with the proposed method. Here we mean with automated exploration pattern that the student is supplied with a computer-assisted navigation system that automatically retrieves and visualizes available hyperlinks to be traversed next from current concept but however student is expected to actively select the next hyperlink to traverse from provided set of alterative hyperlinks. Therefore we compared *traversed hyperlinks* in exploration paths in "hyperlink network of 55 concepts" (n=49) which we consider automated exploration patterns with *conceptual relationships in concept maps* drawn by students (n=103) which we consider non-automated exploration patterns. In this current analysis, the set of conceptual relationships in concept maps drawn by students is based on same sample that we introduced in Subchapter 3.9 (it is explained in Subchapter 3.9 how we gathered this sample).

In statistical comparison, we found positive correlation among the highest-ranking conceptual relationships between automated and non-automated exploration patterns in various topics with overlap ranging up to 60–70 percent, thus indicating that automated method can fruitfully guide the learner's exploration along paths that are intuitively preferred in non-automated learning. With resembling positive results, we found convincing overlap even when comparing automated exploration patterns of younger learners to non-automated exploration patterns of older learners thus indicating that the method can enhance maturing of learning process. Similarly, the method seemed to enhance how individual conceptual relationships agglomerated and concept maps matured along the exploration. It thus seems that the method can support learning with recommendations based on traversing hyperlink chains to form the closest mappings between all concepts of the learning concept networks.

Table 9.1 enables comparison of the highest-ranking core relationships[1] in concept maps drawn by students and the highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (full listing is shown in Appendix N). Table 9.2 enables comparison of rankings of the highest-ranking core relationships of concept maps and the highest-ranking traversed hyperlinks that are shared by both listing of core relationships and listing of traversed hyperlinks (thus showing here all those relationships and hyperlinks indicated with an asterisk (*) in Appendix N).

Table 9.1. Comparison of the highest-ranking core relationships in concept maps drawn by students (n=103) and the highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (n=49), based on listings of Table 3.9 and Appendix K (full listing is show in Appendix N). Those relationships that exist in both listings are indicated with an asterisk (*). This table is limited to shown only those core relationships having at least 6 occurrences and those traversed hyperlinks having at least 13 occurrences, for full listing see Appendix N. The number of traversals for hyperlinks departing from Human (i.e. value 19) includes all those traversals that originate from the fact that in the experiment all exploration paths of students had to start always from concept Human, however in parenthesis (i.e. value 2) is shown the number of traversals when excluding those traversed hyperlinks departing from concept Human that were the student's first traversed hyperlink in exploration path.

Concept maps drawn by the students (n=103)			*Exploration paths in the Wikipedia (n=49)*		
Core relationships (i.e. relationships between 102 core concepts extended with concept "brother" that are mentioned by at least two students in concept maps drawn by students) shown so that each concept is transformed to the closest matching entry of Wikipedia article (relationships of concept maps do not have any specified linking direction, thus each pair of concepts are shown in alphabetical order) (n=103)	*Occurrences (at most one occurrence counted for each student)*	*Ranking*	*Traversed hyperlinks of the Wikipedia in exploration paths of students (n=49)*	*Occurrences (at most one occurrence counted for each student)*	*Ranking*
Family¤Friendship	15	1	Happiness -> Emotion	29	1
* Birth¤Death	13	2s	* Emotion -> Love	26	2
* Family¤Love	13	2s	Joy -> Happiness	24	3s
Friendship¤School	10	3	* Disease -> Death	24	3s
* Family¤Home	9	4s	Happiness -> Joy	21	4
School¤Work	9	4s	Human -> Diet_(nutrition)	19 (2)	5s
* Animal¤Nature	8	5s	Emotion -> Experience	19	5s
* Friendship¤Love	8	5s	Experience -> Emotion (only to roll back)	18	6
* Child¤Family	7	6s	Organism -> Biology	17	7s
Death¤Living	7	6s	Adolescence -> Education	17	7s
* Family¤Father	7	6s	* Love -> Friendship	16	8
Family¤Living	7	6s	Education -> Learning	14	9s
Joy¤Sorrow	7	6s	Learning -> Education	14	9s
* Family¤Mother	6	7s	Emotion -> Happiness	14	9s
* Father¤Mother	6	7s	* Family -> Mother	13	10s
Food¤Water	6	7s	Diet_(nutrition) -> Health	13	10s
Friendship¤Hobby	6	7s	* Health -> Disease	13	10s
Money¤Work	6	7s			

[1] Please note that a specific meaning for term "core relationship" has been defined in Subchapter 3.10.

In contrast with practice used often elsewhere in this publication, in Table 9.1, Table 9.2 and Appendix N if ranking is based on shared ranking positions we have decided to give to all representatives of this shared position the same ranking value which is a ranking value that would have been used next if there was not need for sharing the position (i.e. we now avoid using an average of all ranking values that would have been used if there was not need for sharing the position and skipping corresponding number of ranking values). We decided to use all ranking values even in case of shared ranking so that our analysis about overlap of listing of corresponding highest-ranking core relationships and highest-ranking traversed hyperlinks could become more intuitive in the following text.

Figure 9.4 enables comparison of rankings of *highest-ranking core relationships of concept maps drawn by students* (34 relationships) and *highest-ranking traversed hyperlinks* in exploration paths of students (51 hyperlinks of which 17 are unidirectional and 34 have a hyperlink going also into opposite direction) that are shared by both listing of core relationships of concept maps and listing of traversed hyperlinks (thus showing here all those relationships and hyperlinks indicated with an asterisk (*) in Appendix N).

Based on Table 9.2 we compared listing of highest-ranking core relationships in concept maps drawn by the students (in column 1) and listing of highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (in column 4), this analysis was assisted by a third listing showing traversed hyperlinks of the Wikipedia in exploration paths of students in decreasing order of average of ranking values based on core relationships and traversed hyperlinks (in column 8).

When considering traversed hyperlinks that have a ranking position as high as possible in both listing of corresponding highest-ranking core relationships and highest-ranking traversed hyperlinks based on their average (in column 8) it turned out that four hyperlinks with this kind of highest average ranking positions (Love->Friendship, Disease->Death, Family->Mother and Love->Family) covered four ranking levels of seven first ranking levels for core relationships (based on ranking levels shown in column 3) and four ranking levels of eight first ranking levels for traversed hyperlinks (based on ranking levels shown in column 6). Thus with this sample we concluded that there was an overlap of core relationships and traversed hyperlinks in the range 50–57 percent (4/8=0.50 and 4/7≈0.57).

Similarly when considering eight hyperlinks with this kind of highest average ranking positions in column 8 (Love -> Friendship, Disease -> Death, Family -> Mother, Love -> Family, Emotion -> Love, Animal -> Nature, Health -> Disease, Love -> Happiness) these eight hyperlinks covered eight ranking levels of nine first ranking levels for core relationships (based on ranking levels shown in column 3) and eight ranking levels of ten first ranking levels for traversed hyperlinks (based on ranking levels shown in column 6). Thus with this sample we concluded that there was an overlap of core relationships and traversed hyperlinks in the range 80–89 percent (8/10=0.80 and 8/9≈0.89).

Table 9.2 part 1 of 3 (starts here and continues on next page)**.** Comparison of rankings of the highest-ranking core relationships of concept maps and the highest-ranking traversed hyperlinks that are shared by both listing of core relationships and listing of traversed hyperlinks (thus showing here all those relationships and hyperlinks indicated with an asterisk (*) in Appendix N). To enable comparison of core relationships and traversed hyperlinks each concept of core relationship is transformed to the closest matching entry of Wikipedia article. Based on Table 9.1 and Appendix N (Appendix N shows full listing) this table shows only those core relationships of concept maps drawn by students and traversed hyperlinks of the Wikipedia in exploration paths of students that are shared by both listing of core relationships and listing of traversed hyperlinks (thus showing here all those relationships and hyperlinks indicated with an asterisk (*) in Appendix N). In core relationships concepts are shown so that they are transformed to the closest matching entry of Wikipedia article. In columns 2 and 3 ranking values for core relationships are shown both among all core relationships and among only those core relationships that are shared with traversed hyperlinks of the Wikipedia in exploration paths of students. In columns 5 and 6 ranking values for traversed hyperlinks are shown both among all traversed hyperlinks and among only those traversed hyperlinks that are shared with core relationships. In column 7 ranking values are shown also for a traversed hyperlink going into opposite direction than current traversed hyperlink (if existing). In addition, column 9 shows a listing of traversed hyperlinks of the Wikipedia in exploration paths of students in decreasing order of average of ranking values based on core relationships and traversed hyperlinks. This listing of column 9 aims to suggest a ranking of such relationships and hyperlinks that appear among the highest-ranking positions in both listing of core relationships and traversed hyperlinks, relying on average of ranking values for current hyperlink and corresponding relationship (from columns 3 and 6). Please note that listing of core relationships is shorter than listing of traversed hyperlinks.

Highest-ranking core relationships in concept maps drawn by the students (n=103)			*Highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (n=49)*				*Traversed hyperlinks of the Wikipedia in exploration paths of students in decreasing order of average of ranking values based on core relationships and traversed hyperlinks*	
Core relationships shown so that each concept is transformed to the closest matching entry of Wikipedia article (relationships of concept maps do not have any specified linking direction, each pair of concepts are shown in alphabetical order)	Ranking among all core relationships	Ranking among only those core relationships that are shared with traversed hyperlinks of the Wikipedia in exploration paths of students	Traversed hyperlinks	Ranking among all traversed hyperlinks	Ranking for a traversed hyperlink going into opposite direction than current traversed hyperlink (if existing)	Ranking among only those traversed hyperlinks that are shared with core relationships (so that each concept is transformed to the closest matching entry of Wikipedia article)	Traversed hyperlinks	Average of ranking values for current hyperlink and corresponding relationship (from third and sixth column)
Birth¤Death	2s	1s	Emotion -> Love	2	12s	1	Love -> Friendship	3
Family¤Love	2s	1s	Disease -> Death	3	14s	2	Disease -> Death	4.5s
Family¤Home	4	2	Love -> Friendship	8	20s	3	Family -> Mother	4.5s
Animal¤Nature	5s	3s	Family -> Mother	10s	21s	4s	Love -> Family	4.5s
Friendship¤Love	5s	3s	Health -> Disease	10s		4s	Emotion -> Love	5
Child¤Family	6s	4s	Love -> Happiness	11	18s	5	Animal -> Nature	6.5s
Family¤Father	6s	4s	Friendship -> Adolescence	12s	not existing	6s	Health -> Disease	6.5s
Family¤Mother	7s	5s	Love -> Emotion	12s	2	6s	Love -> Happiness	6.5s
Father¤Mother	7s	5s	Biology -> Nature	13s	not existing	7s	Child -> Family	7s
Nature¤Plant	8s	6s	Human -> Family	13s	not existing	7s	Family -> Child	7s
Plant¤Tree	8s	6s	Oxygen -> Water	13s	19s	7s	Human -> Family	7s
Death¤Disease	9s	7s	Death -> Disease	14s	3	8s	Biology -> Nature	7.5s
Family¤Human	9s	7s	Death -> War	14s	not existing	8s	Death -> Disease	7.5s
Human¤Love	9s	7s	Love -> Family	14s	not existing	8s	Friendship -> Adolescence	7.5s
Human¤Nature	9s	7s	Family -> Sibling	15s	20s	9s	Love -> Emotion	7.5s

Table 9.2 part 2 of 3 (started on previous page and continues here)**.**

Highest-ranking core relationships in concept maps drawn by the students (n=103)			*Highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (n=49)*				*Traversed hyperlinks of the Wikipedia in exploration paths of students in decreasing order of average of ranking values based on core relationships and traversed hyperlinks*	
Core relationships shown so that each concept is transformed to the closest matching entry of Wikipedia article (relationships of concept maps do not have any specified linking direction, each pair of concepts are shown in alphabetical order)	Ranking among all core relationships	Ranking among only those core relationships that are shared with traversed hyperlinks of the Wikipedia in exploration paths of students	Traversed hyperlinks	Ranking among all traversed hyperlinks	Ranking for a traversed hyperlink going into opposite direction than current traversed hyperlink (if existing)	Ranking among only those traversed hyperlinks that are shared with core relationships (so that each concept is transformed to the closest matching entry of Wikipedia article)	Traversed hyperlinks	Average of ranking values for current hyperlink and corresponding relationship (from third and sixth column)
Animal¤Human	10s	8s	Plant -> Tree	15s	not existing	9s	Nature -> Animal	7.5s
Biology¤Nature	10s	8s	Sea -> Water	15s	15s	9s	Plant -> Tree	7.5s
Death¤Human	10s	8s	Water -> Sea	15s	15s	9s	Birth -> Death	8s
Death¤Old_age	10s	8s	Animal -> Human	16s	21s	10s	Death -> War	8s
Death¤War	10s	8s	Animal -> Nature	16s	18s	10s	Family -> Father	8s
Education¤School	10s	8s	Child -> Family	16s	16s	10s	Home -> Family	8s
Food¤Health	10s	8s	Death -> Human	16s	not existing	10s	Oxygen -> Water	8s
Happiness¤Love	10s	8s	Education -> School	16s	16s	10s	Plant -> Nature	8s
Home¤House	10s	8s	Family -> Child	16s	16s	10s	Father -> Family	8.5s
Nature¤Sun	10s	8s	Mother -> Love	16s	not existing	10s	Friendship -> Love	8.5s
Adolescence¤Friendship	11s	9s	Plant -> Nature	16s	19s	10s	Animal -> Human	9s
Disease¤Health	11s	9s	School -> Education	16s	16s	10s	Death -> Human	9s
Emotion¤Love	11s	9s	Teacher -> School	17	18s	11	Education -> School	9s
Family¤Sibling	11s	9s	Family -> Father	18s	19s	12s	Family -> Sibling	9s
Leisure¤Television	11s	9s	Happiness -> Love	18s	11	12s	School -> Education	9s
Love¤Mother	11s	9s	Nature -> Animal	18s	16s	12s	Sea -> Water	9s
Oxygen¤Water	11s	9s	Nature -> Human	18s	not existing	12s	Water -> Sea	9s
School¤Teacher	11s	9s	School -> Teacher	18s	17	12s	Father -> Mother	9.5s
Sea¤Water	11s	9s	Father -> Family	19s	18s	13s	Mother -> Father	9.5s
			Human -> Love	19s	not existing	13s	Mother -> Love	9.5s

Table 9.2 part 3 of 3 (started two pages earlier and continues here)**.**

Highest-ranking core relationships in concept maps drawn by the students (n=103)			*Highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (n=49)*				*Traversed hyperlinks of the Wikipedia in exploration paths of students in decreasing order of average of ranking values based on core relationships and traversed hyperlinks*	
Core relationships shown so that each concept is transformed to the closest matching entry of Wikipedia article (relationships of concept maps do not have any specified linking direction, each pair of concepts are shown in alphabetical order)	Ranking among all core relationships	Ranking among only those core relationships that are shared with traversed hyperlinks of the Wikipedia in exploration paths of students	Traversed hyperlinks	Ranking among all traversed hyperlinks	Ranking for a traversed hyperlink going into opposite direction than current traversed hyperlink (if existing)	Ranking among only those traversed hyperlinks that are shared with core relationships (so that each concept is transformed to the closest matching entry of Wikipedia article)	Traversed hyperlinks	Average of ranking values for current hyperlink and corresponding relationship (from third and sixth column)
			Nature -> Plant	19s	16s	13s	Nature -> Human	9.5s
			Nature -> Sun	19s	not existing	13s	Nature -> Plant	9.5s
			Old_age -> Death	19s	not existing	13s	Happiness -> Love	10s
			Water -> Oxygen	19s	13s	13s	Human -> Love	10s
			Father -> Mother	20s	20s	14s	Mother -> Family	10s
			Friendship -> Love	20s	8	14s	Teacher -> School	10s
			Home -> Family	20s	not existing	14s	Nature -> Sun	10.5s
			House -> Home	20s	not existing	14s	Old_age -> Death	10.5s
			Mother -> Father	20s	20s	14s	School -> Teacher	10.5s
			Sibling -> Family	20s	15s	14s	House -> Home	11s
			Birth -> Death	21s	not existing	15s	Water -> Oxygen	11s
			Health -> Food	21s	not existing	15s	Health -> Food	11.5s
			Human -> Animal	21s	16s	15s	Human -> Animal	11.5s
			Leisure -> Television	21s	21s	15s	Sibling -> Family	11.5s
			Mother -> Family	21s	10s	15s	Leisure -> Television	12s
			Television -> Leisure (only to roll back)	21s	21s	15s	Television -> Leisure (only to roll back)	12s

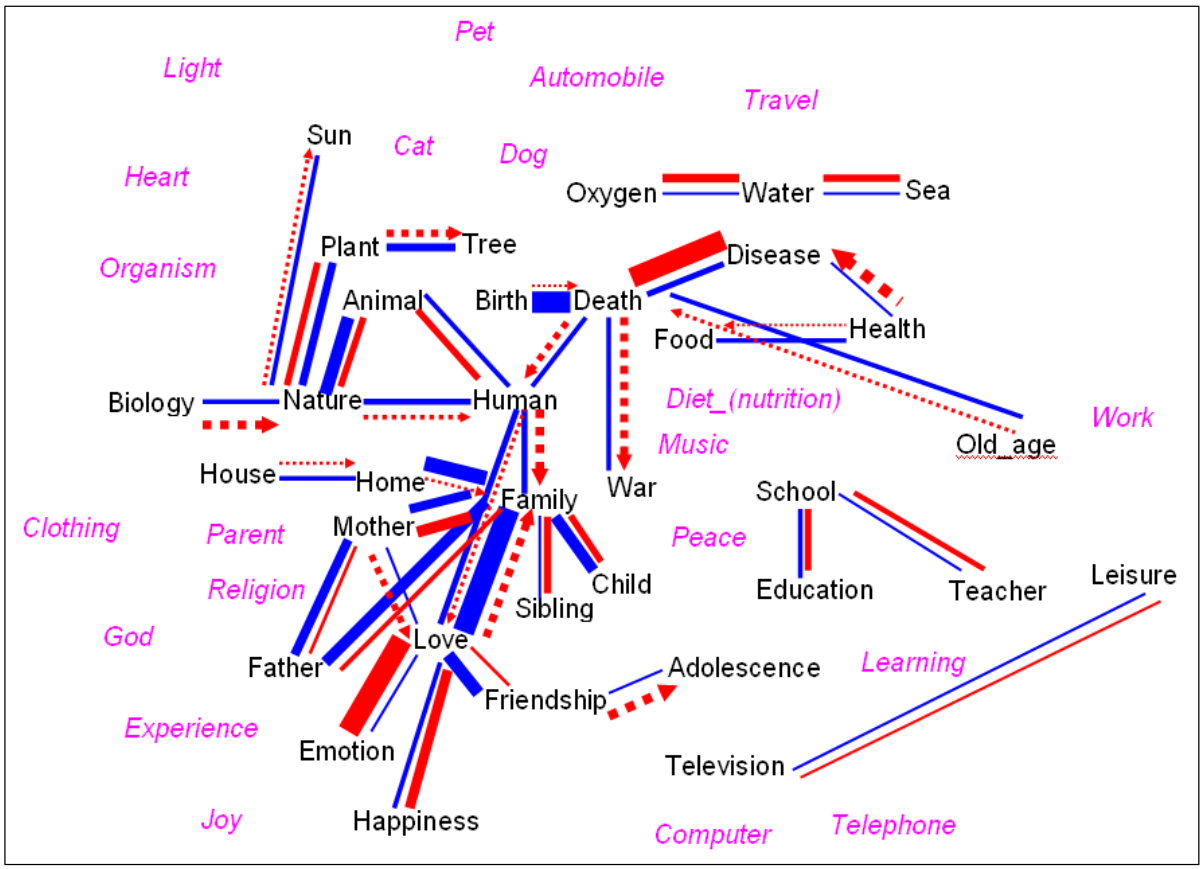

Figure 9.4. Based on Table 9.2 this figure shows only those core relationships of concept maps drawn by students (n=103) and traversed hyperlinks of the Wikipedia in exploration paths of students (n=49) that are shared by both listing of core relationships of concept maps and listing of traversed hyperlinks (thus showing here all those relationships and hyperlinks indicated with an asterisk (*) in Appendix N). Figure contains all 55 concepts that were available for exploration paths of students and concepts written in pink color do not belong to those core relationships of concept maps and traversed hyperlinks that are shared by both listings (each concept is transformed to the closest matching entry of Wikipedia article). Core relationships of concept maps are shown with blue lines and traversed hyperlinks with red lines. Greater width of line indicates higher position in ranking among those core relationships of concept maps and traversed hyperlinks that are shared by both listings, and the range of line widths is normalized for both listings to enable direct comparability. If there is a traversed hyperlink in both directions between two concepts the connection is supplied with a solid line and the higher one of two available line widths is shown. If there is a traversed hyperlink in only in one direction between two concepts the connection is supplied with a dotted line that indicates direction with an arrow.

Distinctive exploration patterns in collective concept mapping for different collaborator roles based on Competing Values Framework (corresponding to analysis in Subchapter 4.3 of Lauri Lahti's doctoral dissertation "Computer-assisted learning based on cumulative vocabularies, conceptual networks and Wikipedia linkage")

In publication [1] we have listed some common tasks for the suggested collaborative learning platform that are associated with each quadrant of Competing Values Framework model (see Table 4.1 (modified version of Table 1 originally published in publication [P1])). We think that tracking these tasks can enable generating automatically appropriate personal support for activities of each collaborator role. Our aim was to identify and describe some activities typically for using user interface of a computer application.

Table 4.1 (modified version of Table 1 originally published in publication [P1])**.** Suggestion of some typical tasks for collaborator roles based on Competing Values Framework (CVF).

Innovator-broker role (create)	*Producer-director role (compete)*	*Coordinator-monitor role (control)*	*Facilitator-mentor role (collaborate)*
- submits a lot of ideas - explores accordance of ideas and concept map - adds nodes to concept map - questions constraints	- sets goals for ideation - maintains holistic efficiency - comments concept map - aims at logic flow	- comments ideas - synthesizes ideas to map - edits concept map - references to ideas	- aims at agreement by personal messaging - distributes topics from concept map for reconsideration - adds arcs to concept map - references to concept map

By analysing lists of typical activities identified for each collaborator role ((Quinn & Rohrbaugh 1983); (DeGraff & Quinn 2006); (Carte et al. 2006); (Pounder 2000); (Noypayak & Speece 1998)) we heuristically proposed in publication [P1] coarse frequency distributions for some activities performed with a collaborative learning platform. As we emphasized in publication [P1], the proposed coarse relative activity frequencies tried to loosely indicate how some activities are expected to be performed more by certain collaborator roles than by others. We suggested that empirical testing is needed to acquire actual frequency values. After publication of the publication [P1] we carried out empirical experiments with 66 students having ages in range 15–18 years and representing four roles of Competing Values Framework and we evaluated their collaborative concept map construction process in small groups. For each student we identified which of four major collaborator roles (shown in Table 4.1 (modified version of Table 1 published in publication [P1])) he represents by a questionnaire. Among these 66 students 24 represented Producer-director role (compete), 14 Innovator-broker role (create), 14 Coordinator-monitor role (control) and 14 Facilitator-mentor role (collaborate).

Without revealing in advance what is the purpose of the questionnaire we asked the student to fill in a competing values self-assessment questionnaire that is adapted from Quinn et al. ((Quinn et al. 1990, especially table 1.2 on page 21); (Quinn et al. 1996, especially table 1.2 on pages 23–24)) (shown in Appendix T) and among the six sets of four questions corresponding to each four major collaborator roles that role which received the highest number of points was selected as the role of the student for collaborative concept map construction process in small groups. In the questionnaire questions 1–6 concern having characteristics of innovator-broker role, then questions 7–12 producer-director role, next questions 13–18 coordinator-monitor role and finally then questions 19–24 facilitator-mentor role. Based on activities and dialogue we recorded for the individual

members of groups we gained a collection of statistical data that represents five persons for each of four of collaborator roles of Competing Values Framework, together twenty persons (n=20), shown in Table 4.2. Even if sample sizes remain small we think that this experiment offered useful preliminary results.

We decided to use *one-way analysis of variance (ANOVA)* to test for differences in occurrences of twelve activities among four roles of Competing Values Framework based on values shown in Table 4.2 so that we considered so called F value representing the ratio of variance between groups to variance within groups. Before carrying out analysis of variance, we tested data for homogeneity of variance with Fligner-Killeen test of homogeneity of variance that has been considered robust to data that is not normally distributed and this test has a null hypothesis Hfk that variances for all samples are equal. It turned out that Fligner-Killeen test of homogeneity of variance for occurrences of twelve activities among four roles of Competing Values Framework, when considering occurrences by each role as samples for an activity, produced p-values in range from 0.09226 to 0.9787 thus meaning that the null hypothesis Hfk was not rejected at $p<0.05$.

According to one-way ANOVA, occurrences did not differ significantly among four roles in respect to following activities (since F values remained below critical value of 3.239 that corresponds to degrees of freedom $df_{within\_groups}=20-4=16$ and $df_{between\_groups}=4-1=3$ at $p<0.05$): submiting ideas ($F(3.16)=2.764$; $p = 0.0759$), adding nodes to concept map ($F(3.16)=1.565$; $p=0.237$), adding arcs to concept map ($F(3.16)=0.785$; $p=0.519$), making references to ideas ($F(3.16)=0.187$; $P=0.904$), making and references to concept map ($F(3.16)=0.591$; $p=0.63$), commenting concept map ($F(3.16)=1.087$; $p=0.383$), synthesizing ideas to concept map ($F(3.16)=1.064$; $p=0.392$), distributing topics from concept map for reconsideration ($F(3.16)=0.349$; $p=0.79$), exploring accordance of ideas and concept map ($F(3.16)=0.69$; $p=0.572$), and requesting stimulation for creative thinking ($F(3.16)=0.139$; $p=0.935$).

On the other hand according to one-way ANOVA, occurrences differed significantly among four roles in respect to following two activities (since F values exceeded critical value of 3.239 that corresponds to degrees of freedom $df_{within\_groups}=20-4=16$ and $df_{between\_groups}=4-1=3$ at $p<0.05$): commenting ideas ($F(3.16)=6.39$; $p=0.00472$) and sending coordination messages ($F(3.16)=5.967$; $p=0.00626$). Thus these two activities both required a *Tukey post-hoc test*.

Concerning activity of commenting ideas, Tukey post-hoc comparison of four roles was carried out and it indicated that role of coordinator-monitor (mean 6.0) had significantly higher occurrences than role of innovator-broker (mean 2.0) at $p=0.0064730$; and it indicated also that role of facilitator-mentor (mean 5.4) had significantly higher occurrences than role of innovator-broker (mean 2.0) at $p=0.0210340$; whereas other Tukey post-hoc comparisons were not statistically significant at $p<0.05$.

Table 4.2. Occurrences of twelve activities among four collaborator roles of Competing Values Framework so that each role represented by five persons (n=20).

Groups of Competing Values Framework collaborator roles and their members	*Submits ideas*	*Adds nodes to concept map*	*Adds arcs to concept map*	*Makes references to ideas*	*Makes references to concept map*	*Comments ideas*	*Comments concept map*	*Sends coordination messages*	*Synthesizes ideas to concept map*	*Distributes topics from concept map for reconsideration*	*Explores accordance of ideas and concept map*	*Requests stimulation for creative thinking*
Innovator-broker (create)	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences
Person1	4	6	9	3	1	2	1	5	15	0	0	1
Person2	6	5	5	2	2	2	4	11	10	0	1	4
Person3	8	7	8	1	3	3	3	12	15	0	2	1
Person4	4	4	5	0	2	1	3	6	9	0	2	2
Person5	7	9	13	5	4	2	4	8	22	2	1	2
Average	5.8	6.2	8	2.2	2.4	2	3	8.4	14.2	0.4	1.2	2
Variance	3.2	3.7	11	3.7	1.3	0.5	1.5	9.3	26.7	0.8	0.7	1.5
Proportion of group	0.187097	0.229633	0.232558	0.314286	0.181818	0.119048	0.176471	0.168	0.23127	0.222222	0.103448	0.277778
Producer-director (compete)	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences
Person6	3	4	4	2	2	2	4	5	8	0	0	1
Person7	5	10	13	0	6	2	7	11	23	2	3	3
Person8	5	6	5	5	3	5	4	12	11	0	23	2
Person9	6	7	8	0	4	4	6	13	15	0	2	0
Person10	8	3	5	2	2	4	4	14	8	1	1	3
Average	5.4	6	7	1.8	3.4	3.4	5	11	13	0.6	5.8	1.8
Variance	3.3	7.5	13.5	4.2	2.8	1.8	2	12.5	39.5	0.8	93.7	1.7
Proportion of group	0.174194	0.222222	0.203488	0.257143	0.257576	0.202381	0.294118	0.22	0.211726	0.333333	0.5	0.25
Coordinator-monitor (control)	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences
Person11	2	6	6	1	1	6	3	10	12	0	1	0
Pesron12	14	7	7	2	1	8	1	25	14	1	2	6
Person13	18	6	16	1	8	3	8	21	22	1	1	0
Person14	7	9	12	2	6	9	8	17	21	0	0	0
Person15	13	4	7	1	4	4	4	17	11	1	7	1
Average	10.8	6.4	9.6	1.4	4	6	4.8	18	16	0.6	2.2	1.4
Variance	39.7	3.3	18.3	0.3	9.5	6.5	9.7	31	26.5	0.3	7.7	6.8
Proportion of group	0.348387	0.237037	0.27907	0.2	0.30303	0.357143	0.282353	0.36	0.260586	0.333333	0.189655	0.194444
Facilitator-mentor (collaborate)	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences	Occurrences
Person16	8	10	8	5	3	4	5	12	18	0	1	2
Person17	11	7	9	1	2	7	2	12	16	0	0	1
Person18	9	8	11	2	5	6	5	15	19	0	9	4
Person19	10	9	12	0	3	4	4	13	21	0	2	2
Person20	7	8	9	0	4	6	5	11	17	1	0	1
Average	9	8.4	9.8	1.6	3.4	5.4	4.2	12.6	18.2	0.2	2.4	2
Variance	2.5	1.3	2.7	4.3	1.3	1.8	1.7	2.3	3.7	0.2	14.3	1.5
Proportion of group	0.290323	0.311111	0.284884	0.228571	0.257576	0.321429	0.247059	0.252	0.296417	0.111111	0.206897	0.277778
All groups												
Sum of occurrences	155	135	172	35	66	84	85	250	307	9	58	36
F values of ANOVA	2.764	1.565	0.7853	0.1867	0.5906	6.390	1.087	5.967	1.064	0.3492	0.6896	0.1391

Concerning activity of sending coordination messages, Tukey post-hoc comparison of four roles was carried out and it indicated that role of coordinator-monitor (mean value 18.0) had significantly higher occurrences than role of innovator-broker (mean value 8.4) at $p=0.0042674$; and it indicated also that role of coordinator-monitor (mean value 18.0) had significantly higher occurrences than role of producer-director (mean value 11.0) at $p=0.0395745$; whereas other Tukey post-hoc comparisons were not statistically significant at $p<0.05$.

These just described results of one-way ANOVA should be considered with some uncertainty, for example due to limited sample sizes, but they offer some insight for modeling activity patterns of four different roles of Competing Values Framework.

Based on Table 4.2 we still wanted to present in compact form the frequency distributions for collaborative activities in respect to each four major collaborator role in Table 4.3 (modified version of Table 2 originally published in publication [P1]). These new empirical values differ from the previous values heuristically suggested in publication [P1] and we suggest that these new frequency distributions should be given priority when implementing an automated monitoring and guidance system for creative collaborative work as suggested in publication [P1]. The more general listing of activities in Table 4.1 (modified version of Table 1 originally published in publication [P1]) is slightly reformulated in Table 4.3 (modified version of Table 2 originally published in publication [P1]) to suit more specific context of the collaborative learning platform implemented with prototype.

As already mentioned, in our proposed method each collaborator is asked to fill in a self-assessment questionnaire adapted from Quinn et al. ((Quinn et al. 1990, especially table 1.2 on page 21); (Quinn et al. 1996, especially table 1.2 on pages 23–24)) to identify her dominant collaborator role in respect to Competing Values Framework. However sometimes it can turn out that the persons available for collaboration do not have a balanced distribution of all four collaborator roles. To address also these situations, we suggest that based on the set of questions of questionnaire receiving the highest number of points the most matching collaborator roles are given to participants but an additional requirement is to ensure that each of the four roles are taken by someone and with less than four persons requires a person being responsible for several roles. Thus sometimes a person needs to take a collaborator role that is not the most dominant for her but anyway she is among the available persons the person who has received the highest number of points in respect to set of questions concerning that role.

We think that each collaborating group benefits from having a freedom to decide itself about practical guidelines for practically performing their creative work together, including sharing responsibilities and agreeing on timing patterns. We think that the complementing efforts from each collaborator should be let to be generated spontaneously without any strict predefined constraints. Anyway, to support exploitation of the specific complementing strengths of each collaborator we propose that a collaborative learning platform monitors activity patterns of each collaborator role and if they differ sufficiently from the expected activity profiles the system asks the representatives of this role to adjust that activity to follow the expected profile. This practise aims to ensure most productive collaboration. For example, the system can measure activity distribution during preceding 5 minutes and if the measured activity of a collaborator differs with a sufficient number of percents from her expected activity profile she will be informed and asked to adjust her activity to more closely match expected activity profile. If the situation does not change after three reminders the system sends a notice also to other collaborators. In publication [P1] we suggested

that if activity departs from expected activity profile over 20 percent the system intervenes but based on later experiments we suggest giving tolerance for variation until the activity frequencies reach a new maximum or a minimum value, as discussed later in this Chapter 4.

Table 4.3 (modified version of Table 2 originally published in publication [P1])**.** Some empirically gained activity frequencies for 12 activities among four collaborator roles of Competing Values Framework so that each role represented by five persons (n=20). For each activity the highest activity frequency is supplied with an asterisk (*) and if there are more than one activity sharing this highest value all of them are supplied with a double asterisk (**). For example, in a collaborative ideation session a person having Innovator-broker role is expected to contribute about 18.7 percent of all activities dealing with "submitting ideas", Producer-director about 17.4 percent, Coordinator-monitor about 34.8 percent and Facilitator-mentor about 29.0 percent respectively. These empirically gained values can be contrasted with heuristically approximated values that we published in publication [P1] and can be seen in Appendix R.

Type of activity	*Innovator-broker role (create)*	*Producer-director role (compete)*	*Coordinator-monitor role (control)*	*Facilitator-mentor role (collaborate)*	*Σ*
Submits ideas	0.187096774	0.174193548	0.348387097*	0.290322581	1.000
Adds nodes to concept map	0.22962963	0.222222222	0.237037037	0.311111111*	1.000
Adds arcs to concept map	0.23255814	0.203488372	0.279069767	0.284883721*	1.000
Makes references to ideas	0.314285714*	0.257142857	0.200000000	0.228571429	1.000
Makes references to concept map	0.181818182	0.257575758	0.303030303*	0.257575758	1.000
Comments ideas	0.119047619	0.202380952	0.357142857*	0.321428571	1.000
Comments concept map	0.176470588	0.294117647*	0.282352941	0.247058824	1.000
Sends coordination messages	0.168000000	0.220000000	0.360000000*	0.252000000	1.000
Synthesizes ideas to concept map	0.231270358	0.211726384	0.260586319	0.296416938*	1.000
Distributes topics from concept map for reconsideration	0.222222222	0.333333333**	0.333333333**	0.111111111	1.000
Explores accordance of ideas and concept map	0.103448276	0.500000000*	0.189655172	0.206896552	1.000
Requests stimulation for creative thinking	0.277777778**	0.250000000	0.194444444	0.277777778**	1.000

It needs to be emphasized that we think that useful activity frequency distributions should be measured for also many other types of activities than those shown in Table 4.3 (modified version of Table 2 originally published in publication [P1]). We think that with increasing number of parallel activity measures it could be possible to offer better guidance for each type of collaborative complementing efforts that can be generated by specific strengths belonging to representatives of each possible collaborator role of Competing Values Framework. Besides Competing Values Framework, we think that also for other types of theoretically motivated collaborator roles it could be possible to similarly identify strengths for each collaborator and the system could monitor that expected activity profiles most fertile for collaboration are met and if not the collaborators are asked to reach the expected activity profiles. Anyway, we decided to limit the scope of publication [P1] to cover estimating the activity frequencies only for the model Competing Values Framework.

It is challenging to empirically measure the pedagogical effect coming from automated guidance that aims to keep activity frequencies of collaborators close to the expected values. Anyway after publication of publication [P1] we carried out empirical user tests that seemed to indicate that learners maintaining their activity frequencies most regularly close to expected values could generate more rich contribution to collaborative process of building knowledge structures than learners maintaining their activity frequencies less regularly close to expected values.

We think that more detailed further analysis of correlation and causality about for example timing practices concerning the distribution of different activities of collaborators and following a specific order of performance can reveal new insight about how each individual collaborator role can proceed in collaboration activities most fruitfully and naturally thus offering best benefits both individually and collectively. Thus by getting more understanding about the characteristics and models governing each collaborator's typical fertile activities the system could then support best the learner by intervening fruitfully and supportingly at moments when it seems that the learners would benefit from doing something specific that however she now has not yet figured out to do.

Individual variation among persons having same collaborator role, causes that the suggested activity frequencies should not be seen as strict values but instead indicating approximate tendencies. Our empirical results with Competing Values Framework show that collaborator role of Coordinator-monitor has leading frequency in four types of activity, Facilitator-mentor has in four types of activity, Producer-director has in three types of activity and Innovator-broker in one type of activity. However, this does not necessitate that role Innovator-broker is more passive than other roles in collaboration in respect to all kinds of imaginable activities. If activity frequencies for additional alternative types of activities are measured in future research it may turn out that the number of leading frequencies for each role and balance of them is completely different. An important task for future research is to try to find most expressive way to classify and identify collaborator roles types, their strengths and measurable activities for each role.

We present now here additional findings and how they can be incorporated into our original model and how they affect our previous analysis and conclusion reported in the publication [P1]. It appeared that our heuristically approximated frequencies (see Appendix R) differed from the experimentally gained frequencies with some major features. Firstly, the heuristically approximated frequencies had a general difference that each unique type of performance had a distribution of frequencies that was unrealistically wide. This means that despite some extreme individual variations, the general average difference between different collaborator roles remains in empirical values only in relatively small range. So instead of having several multiples of other frequencies (other frequencies being even 200–400 percent greater than others) typically we observed at most 200 percent greater frequencies.

Also our later experiments showed that we originally defined a too tight and strict threshold (20 percent) for the monitoring system to intervene with encouraging the user to modify the frequency of the activities belonging to their collaborator role. We now consider that the system should not be directly intervening depending on a fixed percentage in the activity level for a certain collaborator role but instead be relative to the broader distribution pattern of activity frequencies of the collaborator roles. We suggest giving tolerance for variation until the activity frequencies reach a new maximum or a minimum value. This means that for each type of activity the system does not intervene as long as the activity role having the highest value in expected activity frequency profile has not yet been passed above by the collaborator representing another role and as the activity role

having the lowest value in expected activity frequency profile has not yet been passed below by the collaborator representing another role.

As briefly mentioned in publication [P6], our later supplementary empirical experiments with a group of 66 students also indicated that persons representing different collaborator roles based on Competing Values Framework produced distinctive exploration patterns in collective concept mapping as suggested in publication [P1].

Table 4.4 shows the conceptual relationships having the highest number of occurrences for each of four collaborator roles of Competing Values Framework when considering only those relationships mentioned by at least two representatives of this collaborator role (linking direction was not specified in relationships of concept maps). For each collaborator role we have indicated with an asterisk (*) those relationships that do not exist in listings of other collaborator roles in this table. Since among 66 students 24 represented Producer-director role (compete), 14 Innovator-broker role (create), 14 Coordinator-monitor role (control) and 14 Facilitator-mentor role (collaborate) we show for Producer-director role (compete) also values that have been normalized (indicated with a double asterisk (**)) to correspond the same number of students (14) that was the number of students of each of the other roles.

Even if from this small sample strong conclusions cannot be made, in Table 4.4 it seems to us that certain conceptual relationships occurred more frequently in concept mapping by certain collaborator roles of Competing Values Framework, and these promoted relationships can possibly even have same correlations with the characteristics associated with this collaborator role according to Competing Values Framework. Persons representing Innovator-broker role (create) associated with flexibility and readiness promoted for example relationship education¤school. Persons representing Coordinator-monitor role (control) associated with information management and communication promoted for example relationship school¤teacher. Persons representing Producer-director role (compete) associated with planning and goal-setting promoted for example relationship education¤work. Persons representing Facilitator-mentor role (collaborate) associated with cohesion and morale promoted for example relationship animal¤god.

Table 4.4. In exploration patterns in collective concept mapping those conceptual relationships having the highest number of occurrences for each of four collaborator roles of Competing Values Framework when considering only those relationships mentioned by at least two representatives of this collaborator role (linking direction was not specified in relationships of concept maps). For each collaborator role we have indicated with an asterisk (*) those relationships that do not exist in listings of other collaborator roles in this table. Since among 66 students 24 represented Producer-director role (compete), 14 Innovator-broker role (create), 14 Coordinator-monitor role (control) and 14 Facilitator-mentor role (collaborate) we show for Producer-director role (compete) also values that have been normalized (indicated with a double asterisk (**)) to correspond the same number of students (14) that was the number of students of each of the other roles.

Facilitator-mentor role (collaborate) (n=14)		Producer-director role (compete) (n=24)			Coordinator-monitor role (control) (n=14)		Innovator-broker role (create) (n=14)	
relationship	occurrences	relationship	occurrences (n=24)	normalized occurrences ** (estimates corresponding to n=14)	relationship	occurrences	relationship	occurrences
family¤home	3	family¤love	5	2.92	friend¤school	4	joy¤sorrow	3
family¤love	3	food¤water *	4	2.33	father¤mother *	3	birth¤death	2
birth¤death	2	education¤work *	3	1.75	family¤friend *	3	animal¤dog *	2
friend¤love	2	family¤living *	3	1.75	home¤house *	2	friend¤school	2
animal¤god *	2	friend¤love	3	1.75	family¤mother *	2	death¤sorrow *	2
family¤father	2	air¤water *	2	1.17	family¤father	2	death¤living *	2
study¤work *	2	fire¤ground *	2	1.17	child¤wife *	2	cat¤dog	2
death¤nature *	2	air¤ground *	2	1.17	animal¤family *	2	education¤school *	2
birth¤nature *	2	family¤home	2	1.17	friend¤hobby *	2	family¤happyness *	2
living¤purpose *	2	joy¤sorrow	2	1.17	school¤teacher *	2		
		breathing¤human *	2	1.17	school¤work *	2		
		friend¤pet *	2	1.17	birth¤death	2		
					diversity¤nature *	2		
					family¤reproduction *	2		
					birth¤reproduction *	2		
					drink¤food *	2		
					cat¤dog	2		

Based on Table 4.4, Table 4.5 shows the most occurring concepts in conceptual relationships having the highest number of occurrences for each collaborator role of Competing Values Framework when considering only those relationships mentioned by at least two representatives of this collaborator role. For each collaborator role we have indicated with an asterisk (*) those concepts that do not exist in listings of other collaborator roles in this table. Like in Table 4.4 we show also in Table 4.5 for Producer-director role (compete) also values that have been normalized (indicated with a double asterisk (**)) to correspond the same number of students (14) that was the number of students of each of the other roles.

Similarly as with Table 4.4, even if from this small sample strong conclusions cannot be made, in Table 4.5 it seems to us that certain concepts occurred more frequently in concept mapping by certain collaborator roles of Competing Values Framework, and these promoted concepts can possibly even have same correlations with the characteristics associated with this collaborator role according to Competing Values Framework. Persons representing Innovator-broker role (create) associated with flexibility and readiness promoted for example concept happiness. Persons

representing Coordinator-monitor role (control) associated with information management and communication promoted for example concept diversity. Persons representing Producer-director role (compete) associated with planning and goal-setting promoted for example concept breathing. Persons representing Facilitator-mentor role (collaborate) associated with cohesion and morale promoted for example concept god.

Table 4.5. In exploration patterns in collective concept mapping those most occurring concepts in conceptual relationships having the highest number of occurrences for each collaborator role of Competing Values Framework when considering only those relationships mentioned by at least two representatives of this collaborator role (based on Table 4.4). For each collaborator role we have indicated with an asterisk (*) those concepts that do not exist in listings of other collaborator roles in this table. Like in Table 4.4 we show also in Table 4.5 for Producer-director role (compete) also values that have been normalized (indicated with a double asterisk (**)) to correspond the same number of students (14) that was the number of students of each of the other roles.

Facilitator-mentor role (collaborate) (n=14)		Producer-director role (compete) (n=24)			Coordinator-monitor role (control) (n=14)		Innovator-broker role (create) (n=14)	
concept	occurrences	concept	occurrences (n=24)	normalized occurrences ** (estimates corresponding to n=14)	concept	occurrences	concept	occurrences
family	8	family	10	5.83	family	11	death	6
love	5	love	8	4.67	friend	9	sorrow	5
birth	4	water *	6	3.5	school	8	dog	4
death	4	friend	5	2.92	father	5	school	4
nature	4	air *	4	2.33	mother *	5	joy	3
home	3	food	4	2.33	birth	4	animal	2
animal	2	ground *	4	2.33	reproduction *	4	birth	2
father	2	education	3	1.75	animal	2	cat	2
friend	2	living	3	1.75	cat	2	education	2
god *	2	work	3	1.75	child *	2	family	2
living	2	breathing *	2	1.17	death	2	friend	2
purpose *	2	fire *	2	1.17	diversity *	2	happyness *	2
study *	2	home	2	1.17	dog	2	living	2
work	2	human *	2	1.17	drink *	2		
		joy	2	1.17	food	2		
		pet *	2	1.17	hobby *	2		
		sorrow	2	1.17	home	2		
					house *	2		
					nature	2		
					teacher *	2		
					wife *	2		
					work	2		

Interestingly in both Table 4.4 and Table 4.5 it turned out that collaborator roles Producer-director role (compete) and Facilitator-mentor role (collaborate) seemed to have connectivity for concept love and collaborator roles Innovator-broker role (create) and Coordinator-monitor role (control) seemed to have connectivity for concept school. Thus when considering four quadrants of Competing Values Framework the two roles belonging to opposite quadrants seem to possibly be coupled by prioritizing at least to some extent certain concepts and certain relationships.

References:

Lahti, L. (2015a). Computer-assisted learning based on cumulative vocabularies, conceptual networks and Wikipedia linkage. Doctoral dissertation, Department of Computer Science, Aalto University School of Science, Finland.

Lahti, L. (2015b). Supplement to doctoral dissertation "Computer-assisted learning based on cumulative vocabularies, conceptual networks and Wikipedia linkage. Department of Computer Science, Aalto University School of Science, Finland.

Appendix K

Listing of the highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (n=49), shown for all students and also separtely for male students (n=18) and female students (n=31). Exploration experiment with students was carried out in "hyperlink network of 55 concepts" containing 212 hyperlinks connecting 55 concepts. All 212 hyperlinks of "hyperlink network of 55 concepts" are connecting concepts that are reachable (by traversing one or more intermediate hyperlinks) from concept Human in exploration paths (containing 55 concepts including concept Human). This listing shows the number of traversals for those hyperlinks of 212 hyperlinks that became traversed by students and as well as for additional roll back hyperlinks (shown in Appendix J). Please note that in exploration experiment each student was allowed to traverse each hyperlink belonging to "hyperlink network of 55 concepts" at most once (except in case of roll back hyperlinks).

This listing also shows for all students the number of selectable alternative hyperlinks (average) shown to the student when she selected to traverse a hyperlink that was just before traversing current hyperlink. The number of traversals for hyperlinks departing from Human includes all those traversals that originate from the fact that in the experiment all exploration paths of students had to start always from concept Human, however in parenthesis is shown the number of traversals when excluding hyperlinks departing from concept Human that were the student's first traversed hyperlink in exploration path. Indicated with an asterisk (*), for hyperlinks departing from concept Human the number of selectable alternative hyperlinks (average) is calculated only based on those traversals of hyperliks departing from concept Human that were not the student's first traversed hyperlink in her exploration path. Among 16 alterative hyperlinks departing from concept Human there did not occur any traversals for hyperlinks Human->God and Human->Old_age.

All students participating in exploration task (n = 49)				*All male students participating in exploration task (n = 18)*		*All female students participating in exploration task (n = 31)*	
Traversed hyperlink (current hyperlink)	*Number of traversals*	*Number of selectable alternative hyperlinks (average) shown to student when she selected to traverse a hyperlink that was just before traversing current hyperlink*		*Traversed hyperlink*	*Number of traversals*	*Traversed hyperlink*	*Number of traversals*
Happiness -> Emotion	29	3.758621		Animal -> Nature	4	Happiness -> Emotion	25
Emotion -> Love	26	1.846154		Joy -> Happiness	4	Emotion -> Love	23
Joy -> Happiness	24	2.125		Happiness -> Joy	4	Disease -> Death	22
Disease -> Death	24	4.625		Happiness -> Emotion	4	Joy -> Happiness	20
Happiness -> Joy	21	4.285714		Sun -> Oxygen	3	Adolescence -> Education	17
Human -> Diet_(nutrition)	19 (2*)	5.5*		Sun -> Plant	3	Happiness -> Joy	17
Emotion -> Experience	19	7.263158		Biology -> Animal	3	Human -> Diet_(nutrition)	16
Experience -> Emotion (only to roll back)	18	3.833333		Organism -> Biology	3	Emotion -> Experience	16
Organism -> Biology	17	5.176471		Organism -> Plant	3	Experience -> Emotion (only to roll back)	15
Adolescence -> Education	17	6.764706		Organism -> Heart	3	Organism -> Biology	14
Love -> Friendship	16	2.75		Oxygen -> Sun	3	Education ->	14

						Learning	
Education -> Learning	14	3.428571		Oxygen -> Plant	3	Learning -> Education	14
Learning -> Education	14	5.642857		Oxygen -> Water	3	Love -> Friendship	14
Emotion -> Happiness	14	3.571429		Human -> Diet_(nutrition)	3	Family -> Mother	12
Family -> Mother	13	8.384615		Plant -> Nature	3	Health -> Disease	12
Diet_(nutrition) -> Health	13	14.92308		Plant -> Tree	3	Diet_(nutrition) -> Health	11
Health -> Disease	13	10.38462		Experience -> Emotion (only to roll back)	3	Emotion -> Happiness	11
Love -> Happiness	11	6.363636		Happiness -> Love (only to roll back)	3	Emotion -> Joy	10
Emotion -> Joy	11	2.090909		Love -> Happiness	3	Friendship -> Adolescence	10
Love -> Emotion	10	5.4		Emotion -> Experience	3	Biology -> Nature	9
Friendship -> Adolescence	10	5.3		Emotion -> Happiness	3	Human -> Adolescence	9
Biology -> Nature	9	3.444444		Emotion -> Love	3	Adolescence -> Child	9
Organism -> Plant	9	4.888889		Automobile -> Oxygen	2	Love -> Emotion	9
Oxygen -> Water	9	6.333333		Animal -> Organism	2	Human -> Family	8
Human -> Adolescence	9 (2*)	7*		Oxygen -> Automobile	2	Human -> Emotion	8
Human -> Family	9 (6*)	7.333333*		Death -> Organism	2	Experience -> Learning (only to roll back)	8
Human -> Emotion	9 (3*)	6		Nature -> Animal	2	Death -> Disease	8
Adolescence -> Child	9	9.555556		Nature -> Human	2	Death -> War	8
Sun -> Plant	8	5.375		Travel -> Water	2	Learning -> Experience	8
Organism -> Heart	8	5.875		Family -> Father	2	Love -> Happiness	8
Human -> Health	8 (3*)	6.666667*		Tree -> Oxygen	2	War -> Peace	8
Experience -> Learning (only to roll back)	8	1.75		Love -> Biology	2	Biology -> Organism	7
Death -> Disease	8	1.75		Love -> Friendship	2	Human -> Health	7
Death -> War	8	1.75		Diet_(nutrition) -> Organism	2	Family -> Sibling	7
Learning -> Experience	8	7.375		Diet_(nutrition) -> Health	2	Love -> Family	7
Love -> Family	8	3.5		Disease -> Death	2	Organism -> Plant	6
War -> Peace	8	8.5		Sibling -> Love	2	Animal -> Human	6
Mother -> Parent	8	4.5		Heart -> Organism	2	Oxygen -> Water	6
Biology -> Organism	7	5.857143		Health -> Diet_(nutrition)	2	Joy -> Emotion (only to roll back)	6
Biology -> Animal	7	4.142857		Parent -> Sibling	2	School -> Education	6
Oxygen -> Plant	7	6		Water -> Oxygen	2	Education -> School	6
Joy -> Emotion (only to roll back)	7	1.142857		Water -> Travel	2	Education -> Adolescence	6
Plant -> Tree	7	2.571429		Friendship -> Animal	2	Education -> Leisure	6
Sea -> Water	7	7.857143		Mother -> Parent	2	Death -> Human	6
Family -> Sibling	7	9.428571		Biology -> Human	1	Child -> Family	6
Sibling -> Love	7	5.571429		Biology -> Plant	1	Sea -> Water	6
Water -> Sea	7	6.428571		Animal -> Oxygen	1	Teacher -> Learning	6
Sun -> Oxygen	6	3.5		Animal -> Water	1	Family -> Child	6
Animal -> Human	6	5.666667		Oxygen -> Disease	1	Peace -> Education	6
Animal -> Nature	6	7.333333		Human -> Oxygen	1	Water -> Sea	6
Human -> Happiness	6 (5*)	6.6*		Human -> Happiness	1	Mother -> Parent	6
Plant -> Nature	6	4.333333		Human -> Family	1	Sun -> Plant	5
Plant -> Light	6	3.5		Human -> War	1	Organism -> Heart	5
School -> Education	6	3.5		Human -> Health	1	Human -> Happiness	5
Education ->	6	2.833333		Human -> Emotion	1	Plant -> Light	5

School							
Education -> Adolescence	6	2		Human -> Religion	1	Education -> Human	5
Education -> Leisure	6	1.833333		Joy -> Emotion (only to roll back)	1	Education -> Teacher	5
Death -> Organism	6	1		Father -> Family	1	Child -> Adolescence	5
Death -> Human	6	1.333333		Father -> Sibling	1	Teacher -> School	5
Child -> Family	6	3.333333		Father -> Mother	1	Sibling -> Love	5
Teacher -> Learning	6	5.5		God -> Father	1	Health -> Biology	5
Family -> Child	6	6.5		Plant -> Biology	1	Work -> Leisure (only to roll back)	5
Peace -> Education	6	3		Plant -> Animal	1	Parent -> Human	5
Diet_(nutrition) -> Organism	6	13.83333		Plant -> Light	1	Parent -> Birth	5
Heart -> Organism (only to roll back)	6	2.333333		Plant -> Water	1	Leisure -> Work	5
Mother -> Love	6	4.833333		Death -> Heart	1	Mother -> Love	5
Biology -> Human	5	4.8		Nature -> Sun	1	Biology -> Animal	4
Human -> War	5 (3*)	5.666667*		Nature -> Organism	1	Biology -> Human	4
God -> Father	5	3		Nature -> Oxygen	1	Oxygen -> Plant	4
Education -> Human	5	2.2		Sea -> Water	1	Human -> War	4
Education -> Teacher	5	2.4		Family -> Mother	1	Father -> Love	4
Death -> Heart	5	1.6		Tree -> Water	1	God -> Father	4
Child -> Adolescence	5	5.2		Love -> Family	1	Plant -> Tree	4
Teacher -> School	5	4.2		Love -> Emotion	1	School -> Teacher	4
Tree -> Oxygen	5	7.4		Diet_(nutrition) -> Religion	1	Death -> Organism	4
Love -> Biology	5	1.6		Disease -> Oxygen (only to roll back)	1	Death -> Heart	4
Heart -> Death (only to roll back)	5	6.6		Sibling -> Parent	1	Child -> Parent	4
Health -> Biology	5	4		War -> Disease	1	Adolescence -> Old_age	4
Work -> Leisure (only to roll back)	5	4.8		Heart -> Death (only to roll back)	1	Family -> Leisure	4
Religion -> God	5	2.4		Health -> Disease	1	Diet_(nutrition) -> Organism	4
Light -> Sun	5	6.2		Emotion -> Joy	1	War -> Religion	4
Parent -> Human	5	6		Religion -> Sun	1	Heart -> Organism	4
Parent -> Birth	5	6.4		Religion -> God	1	Heart -> Death (only to roll back)	4
Leisure -> Work	5	5.2		Light -> Sun	1	Religion -> God	4
Animal -> Organism	4	4.25		Parent -> Mother	1	Light -> Sun	4
Father -> Love	4	4.75		Water -> Sun	1	Leisure -> Family	4
School -> Teacher	4	9.5		Water -> Human	1	Sun -> Oxygen	3
Child -> Parent	4	4.25		Water -> Plant	1	Human -> Love	3
Nature -> Animal	4	6.5		Water -> Sea	1	Human -> Clothing	3
Nature -> Human	4	6.25		Mother -> Love	1	Plant -> Organism	3
Adolescence -> Old_age	4	9.25				Plant -> Nature	3
Happiness -> Love	4	3				Nature -> Plant	3
Family -> Father	4	5.75				Adolescence -> Television	3
Family -> Leisure	4	7.75				Learning -> Teacher (only to roll back)	3
War -> Religion	4	6.75				Tree -> Oxygen	3
Health -> Diet_(nutrition)	4	7.5				Love -> Biology	3
Leisure -> Family	4	5.25				Diet_(nutrition) -> Death	3
Water -> Sun	4	2.75				Birth -> Animal	3
Oxygen -> Sun	3	5				Television -> Adolescence (only to roll back)	3
Oxygen -> Disease	3	1.333333				Religion -> Human	3
Human -> Love	3 (2*)	7.5*				Old_age -> Death	3

Human -> Religion	3 (0*)	not available since no other hyperlinks were traversed before traversing Human -> Religion*				Water -> Sun	3
Human -> Clothing	3 (2*)	6*				Biology -> Health	2
Father -> Family	3	3.666667				Animal -> Organism	2
Plant -> Organism	3	3				Animal -> Nature	2
Plant -> Water	3	3.333333				Oxygen -> Disease	2
Nature -> Sun	3	6				Oxygen -> Heart	2
Nature -> Organism	3	6.333333				Human -> House	2
Nature -> Oxygen	3	6.666667				Human -> Religion	2
Nature -> Plant	3	6.333333				Father -> Family	2
Travel -> Water	3	7				Father -> Parent	2
Adolescence -> Television	3	7.333333				Plant -> Oxygen	2
Learning -> Teacher (only to roll back)	3	1.666667				Plant -> Water	2
Diet_(nutrition) -> Death	3	12				Home -> Family	2
Sibling -> Parent	3	3.666667				Education -> Biology	2
War -> Disease	3	12.33333				Death -> Oxygen	2
Birth -> Animal	3	6				Nature -> Sun	2
Television -> Adolescence (only to roll back)	3	3.333333				Nature -> Organism	2
Religion -> Human	3	11.33333				Nature -> Animal	2
Old_age -> Death	3	4.333333				Nature -> Oxygen	2
Water -> Oxygen	3	3.333333				Nature -> Human	2
Water -> Plant	3	1				Family -> Father	2
Water -> Travel	3	2				Peace -> War	2
Automobile -> Oxygen	2	6				Sibling -> Family	2
Biology -> Plant	2	2.5				Sibling -> Parent	2
Biology -> Health	2	3				War -> Disease	2
Oxygen -> Automobile	2	2				House -> Home	2
Oxygen -> Heart	2	3.5				Health -> Diet_(nutrition)	2
Human -> Oxygen	2 (1*)	7*				Clothing -> Religion	2
Human -> House	2 (1*)	3*				Light -> Television	2
Father -> Parent	2	5				Parent -> Father	2
Father -> Mother	2	4.5				Parent -> Child	2
Plant -> Biology	2	6				Leisure -> Education	2
Plant -> Animal	2	5				Leisure -> Sibling	2
Plant -> Oxygen	2	7				Water -> Biology	2
Home -> Family	2	4				Water -> Plant	2
Education -> Biology	2	3				Friendship -> Love	2
Death -> Oxygen	2	2.5				Mother -> Father	2
Tree -> Water	2	6				Biology -> Plant	1
Peace -> War	2	3				Human -> Animal	1
Sibling -> Family	2	4.5				Human -> Oxygen	1
House -> Home	2	15.5				Human -> Music	1
Religion -> Sun	2	9				Father -> Mother	1
Clothing -> Religion	2	8.5				Plant -> Biology	1
Light -> Television	2	8				Plant -> Animal	1
Parent -> Father	2	7				Education -> Sibling	1
Parent -> Child	2	5				Child -> Old_age	1
Parent -> Sibling	2	6				Child -> Leisure	1
Leisure -> Education	2	1				Travel -> Water	1
Leisure -> Sibling	2	6				Happiness -> Love	1

						(only to roll back)	
Water -> Biology	2	3.5				Teacher -> Education	1
Friendship -> Animal	2	5.5				Tree -> Water	1
Friendship -> Love	2	5.5				Food -> Human	1
Mother -> Father	2	5				Birth -> Death	1
Animal -> Oxygen	1	7				Birth -> Mother	1
Animal -> Water	1	7				Television -> Clothing (only to roll back)	1
Human -> Animal	1 (0*)	not available since no other hyperlinks were traversed before traversing Human -> Animal*				Television -> Light (only to roll back)	1
Human -> Music	1 (1*)	9*				Television -> Leisure (only to roll back)	1
Father -> Sibling	1	5				Health -> Food	1
Education -> Sibling	1	2				Religion -> Sun	1
Child -> Old_age	1	4				Clothing -> Television	1
Child -> Leisure	1	5				Old_age -> Adolescence	1
Teacher -> Education	1	2				Leisure -> Television	1
Diet_(nutrition) -> Religion	1	4				Water -> Oxygen	1
Food -> Human	1	3				Water -> Travel	1
Disease -> Oxygen (only to roll back)	1	5				Mother -> Family	1
Birth -> Death	1	6					
Birth -> Mother	1	6					
Television -> Clothing (only to roll back)	1	2					
Television -> Light (only to roll back)	1	2					
Television -> Leisure (only to roll back)	1	5					
Health -> Food	1	4					
Clothing -> Television	1	15					
Parent -> Mother	1	7					
Old_age -> Adolescence	1	4					
Leisure -> Television	1	10					
Water -> Human	1	6					
Mother -> Family	1	3					

Appendix N

This listing is based on listings of Table 3.9 and Appendix K to enable comparing the highest-ranking core relationships in concept maps drawn by students (n=103) and traversed hyperlinks of the Wikipedia in exploration paths of students (n=49), and to identify those relationships that exist in both listings, indicated with an asterisk (*).

In columns 1-3 is a list of 145 core relationships that are in fact all those relationships between 102 core concepts extended with concept “brother” that are mentioned by at least two students in concept maps drawn by students (n=103), shown in descending order of occurences in concept maps (based on Table 3.9). However to enable comparison with knowledge structures of the Wikipedia, each concept was transformed to the closest matching entry of Wikipedia articles

according to listing of Appendix F which also explains why Sibling is used to represent concept "brother". Since relationships of concept maps do not have any specified linking direction, each pair of concepts are shown in alphabetical order.

In columns 4-6 is a list of highest-ranking traversed hyperlinks of the Wikipedia in exploration paths of students (n=49), shown for all students (based on Appendix K). Exploration experiment with students was carried out in "hyperlink network of 55 concepts" containing 212 hyperlinks connecting 55 concepts. The number of traversals for hyperlinks departing from Human (for example for Human -> Diet_(nutrition) value 19) includes all those traversals that originate from the fact that in the experiment all exploration paths of students had to start always from concept Human, however in parenthesis (for example for Human -> Diet_(nutrition) value 2) is shown the number of traversals when excluding hyperlinks departing from concept Human that were the student's first traversed hyperlink in exploration path.

Hyperlinks supplied with notation "only to roll back" belong to 14 hyperlinks (shown in Appendix J) that supplement 212 hyperlinks of "hyperlink network of 55 concepts" and were traversed to roll back to previously visited concept when the student's exploration had lead to a next concept that did not offer any outgoing hyperlinks for further exploration or if all outgoing hyperlinks had been already traversed once earlier during this same exploration.

In contrast with practice used often elsewhere in this publication, in Appendix N as well as in Table 9.1 and Table 9.2 if ranking is based on shared ranking positions we have decided to give to all representatives of this shared position the same ranking value which is a ranking value that would have been used next if there were not need for sharing the position (i.e. we now avoid using an average of all ranking values that would have been used if there were not need for sharing the position and skipping corresponding number of ranking values). We decided to use all ranking values even in case of shared ranking so that our analysis about overlap of listing of corresponding highest-ranking core relationships and highest-ranking traversed hyperlinks discussed in Chapter 9 could become more intuitive.

Conceptual network of concept maps drawn by students			Hyperlink network of the Wikipedia		
Core relationships (i.e. relationships between 102 core concepts extended with concept "brother" that are mentioned by at least two students in concept maps drawn by students) shown so that each concept is transformed to the closest matching entry of Wikipedia article (relationships of concept maps do not have any specified linking direction, each pair of concepts are shown in alphabetical order) (n=103)	*Number of occurrences so that at most one occurrence counted for each student*	*Ranking*	*Traversed hyperlinks of the Wikipedia in exploration paths of students (n=49)*	*Number of occurrences so that at most one occurrence counted for each student*	*Ranking*
Family¤Friendship	15	1	Happiness -> Emotion	29	1
* Birth¤Death	13	2s	* Emotion -> Love	26	2
* Family¤Love	13	2s	Joy -> Happiness	24	3s
Friendship¤School	10	3	* Disease -> Death	24	3s
* Family¤Home	9	4s	Happiness -> Joy	21	4
School¤Work	9	4s	Human -> Diet_(nutrition)	19 (2)	5s
* Animal¤Nature	8	5s	Emotion -> Experience	19	5s
* Friendship¤Love	8	5s	Experience -> Emotion (only to roll back)	18	6
* Child¤Family	7	6s	Organism -> Biology	17	7s
Death¤Living	7	6s	Adolescence -> Education	17	7s
* Family¤Father	7	6s	* Love -> Friendship	16	8
Family¤Living	7	6s	Education -> Learning	14	9s
Joy¤Sorrow	7	6s	Learning -> Education	14	9s
* Family¤Mother	6	7s	Emotion -> Happiness	14	9s
* Father¤Mother	6	7s	* Family -> Mother	13	10s
Food¤Water	6	7s	Diet_(nutrition) -> Health	13	10s

Friendship¤Hobby	6	7s	* Health -> Disease	13	10s
Money¤Work	6	7s	* Love -> Happiness	11	11s
Birth¤Living	5	8s	Emotion -> Joy	11	11s
Education¤Work	5	8s	* Love -> Emotion	10	12s
Living¤Nature	5	8s	* Friendship -> Adolescence	10	12s
* Nature¤Plant	5	8s	* Biology -> Nature	9	13s
* Plant¤Tree	5	8s	Organism -> Plant	9	13s
Study¤Work	5	8s	* Oxygen -> Water	9	13s
Animal¤Dog	4	9s	Human -> Adolescence	9 (2)	13s
Atmosphere_of_Earth¤Water	4	9s	* Human -> Family	9 (6)	13s
Cat¤Dog	4	9s	Human -> Emotion	9 (3)	13s
Computer¤Television	4	9s	Adolescence -> Child	9	13s
* Death¤Disease	4	9s	Sun -> Plant	8	14s
Death¤Health	4	9s	Organism -> Heart	8	14s
Family¤Happiness	4	9s	Human -> Health	8 (3)	14s
* Family¤Human	4	9s	Experience -> Learning (only to roll back)	8	14s
Friendship¤Happiness	4	9s	* Death -> Disease	8	14s
Friendship¤Human	4	9s	* Death -> War	8	14s
Friendship¤Joy	4	9s	Learning -> Experience	8	14s
Home¤LIving	4	9s	* Love -> Family	8	14s
Human¤Living	4	9s	War -> Peace	8	14s
* Human¤Love	4	9s	Mother -> Parent	8	14s
* Human¤Nature	4	9s	Biology -> Organism	7	15s
Living¤Work	4	9s	Biology -> Animal	7	15s
Nature¤Water	4	9s	Oxygen -> Plant	7	15s
Animal¤Family	3	10s	Joy -> Emotion (only to roll back)	7	15s
Animal¤Food	3	10s	* Plant -> Tree	7	15s
* Animal¤Human	3	10s	* Sea -> Water	7	15s
* Biology¤Nature	3	10s	* Family -> Sibling	7	15s
Birth¤Health	3	10s	Sibling -> Love	7	15s
* Death¤Human	3	10s	* Water -> Sea	7	15s
* Death¤Old_age	3	10s	Sun -> Oxygen	6	16s
Death¤Sorrow	3	10s	* Animal -> Human	6	16s
* Death¤War	3	10s	* Animal -> Nature	6	16s
Dog¤Family	3	10s	Human -> Happiness	6 (5)	16s
Dog¤Pet	3	10s	* Plant -> Nature	6	16s
* Education¤School	3	10s	Plant -> Light	6	16s
Family¤House	3	10s	* School -> Education	6	16s
Family¤Joy	3	10s	* Education -> School	6	16s
Family¤Work	3	10s	Education -> Adolescence	6	16s
* Food¤Health	3	10s	Education -> Leisure	6	16s
Food¤Living	3	10s	Death -> Organism	6	16s
Friendship¤Party	3	10s	* Death -> Human	6	16s
Ground¤Water	3	10s	* Child -> Family	6	16s
* Happiness¤Love	3	10s	Teacher -> Learning	6	16s
Hobby¤Leisure	3	10s	* Family -> Child	6	16s
Hobby¤School	3	10s	Peace -> Education	6	16s
* Home¤House	3	10s	Diet_(nutrition) -> Organism	6	16s
Home¤School	3	10s	Heart -> Organism (only to roll back)	6	16s
Home¤Work	3	10s	* Mother -> Love	6	16s
Living¤Religion	3	10s	Biology -> Human	5	17s
Living¤School	3	10s	Human -> War	5 (3)	17s
Living¤Water	3	10s	God -> Father	5	17s
* Nature¤Sun	3	10s	Education -> Human	5	17s
School¤Study	3	10s	Education -> Teacher	5	17s
* Adolescence¤Friendship	2	11s	Death -> Heart	5	17s
Animal¤Environment	2	11s	Child -> Adolescence	5	17s
Animal¤God	2	11s	* Teacher -> School	5	17s
Animal¤Tree	2	11s	Tree -> Oxygen	5	17s
Atmosphere_of_Earth¤Ground	2	11s	Love -> Biology	5	17s
Automobile¤Family	2	11s	Heart -> Death (only to roll back)	5	17s
Automobile¤House	2	11s	Health -> Biology	5	17s
Birth¤Child	2	11s	Work -> Leisure (only to roll back)	5	17s
Birth¤Family	2	11s	Religion -> God	5	17s
Birth¤Growing	2	11s	Light -> Sun	5	17s
Birth¤Human	2	11s	Parent -> Human	5	17s
Birth¤Nature	2	11s	Parent -> Birth	5	17s

Book¤School	2	11s	Leisure -> Work	5	17s
Chair¤House	2	11s	Animal -> Organism	4	18s
Child¤Hospital	2	11s	Father -> Love	4	18s
Child¤Human	2	11s	* School -> Teacher	4	18s
Clock¤Computer	2	11s	Child -> Parent	4	18s
Clock¤School	2	11s	* Nature -> Animal	4	18s
Clothing¤Shoe	2	11s	* Nature -> Human	4	18s
Computer¤Leisure	2	11s	Adolescence -> Old_age	4	18s
Death¤Nature	2	11s	* Happiness -> Love	4	18s
Diet_(nutrition)¤Water	2	11s	* Family -> Father	4	18s
* Disease¤Health	2	11s	Family -> Leisure	4	18s
Dream¤Health	2	11s	War -> Religion	4	18s
Education¤Living	2	11s	Health -> Diet_(nutrition)	4	18s
* Emotion¤Love	2	11s	Leisure -> Family	4	18s
Environment¤Family	2	11s	Water -> Sun	4	18s
Environment¤Nature	2	11s	Oxygen -> Sun	3	19s
Experience¤Work	2	11s	Oxygen -> Disease	3	19s
Family¤Health	2	11s	* Human -> Love	3 (2)	19s
Family¤Hobby	2	11s	Human -> Religion	3 (0)	19s
Family¤Money	2	11s	Human -> Clothing	3 (2)	19s
Family¤Pet	2	11s	* Father -> Family	3	19s
* Family¤Sibling	2	11s	Plant -> Organism	3	19s
Family¤Study	2	11s	Plant -> Water	3	19s
Family¤Telephone	2	11s	* Nature -> Sun	3	19s
Father¤Home	2	11s	Nature -> Organism	3	19s
Food¤Television	2	11s	Nature -> Oxygen	3	19s
Friendship¤Leisure	2	11s	* Nature -> Plant	3	19s
Friendship¤Living	2	11s	Travel -> Water	3	19s
Friendship¤Pet	2	11s	Adolescence -> Television	3	19s
Friendship¤Sibling	2	11s	Learning -> Teacher (only to roll back)	3	19s
Friendship¤Study	2	11s	Diet_(nutrition) -> Death	3	19s
Friendship¤Work	2	11s	Sibling -> Parent	3	19s
God¤Organism	2	11s	War -> Disease	3	19s
Ground¤Nature	2	11s	Birth -> Animal	3	19s
Health¤Light	2	11s	Television -> Adolescence (only to roll back)	3	19s
Health¤Old_age	2	11s	Religion -> Human	3	19s
Health¤Physical_fitness	2	11s	* Old_age -> Death	3	19s
Heart¤Love	2	11s	* Water -> Oxygen	3	19s
Hobby¤Work	2	11s	Water -> Plant	3	19s
Holiday¤Party	2	11s	Water -> Travel	3	19s
Holiday¤Work	2	11s	Automobile -> Oxygen	2	20s
Home¤Mother	2	11s	Biology -> Plant	2	20s
House¤Work	2	11s	Biology -> Health	2	20s
Joy¤Living	2	11s	Oxygen -> Automobile	2	20s
Joy¤Love	2	11s	Oxygen -> Heart	2	20s
Learning¤Love	2	11s	Human -> Oxygen	2 (1)	20s
* Leisure¤Television	2	11s	Human -> House	2 (1)	20s
Living¤Music	2	11s	Father -> Parent	2	20s
Living¤Organism	2	11s	* Father -> Mother	2	20s
Living¤Peace	2	11s	Plant -> Biology	2	20s
Living¤Purpose	2	11s	Plant -> Animal	2	20s
Living¤Sorrow	2	11s	Plant -> Oxygen	2	20s
Living¤Sun	2	11s	* Home -> Family	2	20s
Living¤Travel	2	11s	Education -> Biology	2	20s
* Love¤Mother	2	11s	Death -> Oxygen	2	20s
Love¤Nature	2	11s	Tree -> Water	2	20s
Love¤Parent	2	11s	Peace -> War	2	20s
Nature¤Tree	2	11s	* Sibling -> Family	2	20s
* Oxygen¤Water	2	11s	* House -> Home	2	20s
* School¤Teacher	2	11s	Religion -> Sun	2	20s
* Sea¤Water	2	11s	Clothing -> Religion	2	20s
Summer¤Sun	2	11s	Light -> Television	2	20s
			Parent -> Father	2	20s
			Parent -> Child	2	20s
			Parent -> Sibling	2	20s
			Leisure -> Education	2	20s
			Leisure -> Sibling	2	20s
			Water -> Biology	2	20s
			Friendship -> Animal	2	20s

			* Friendship -> Love	2	20s
			* Mother -> Father	2	20s
			Animal -> Oxygen	1	21s
			Animal -> Water	1	21s
			* Human -> Animal	1 (0)	21s
			Human -> Music	1 (1)	21s
			Father -> Sibling	1	21s
			Education -> Sibling	1	21s
			Child -> Old_age	1	21s
			Child -> Leisure	1	21s
			Teacher -> Education	1	21s
			Diet_(nutrition) -> Religion	1	21s
			Food -> Human	1	21s
			Disease -> Oxygen (only to roll back)	1	21s
			* Birth -> Death	1	21s
			Birth -> Mother	1	21s
			Television -> Clothing (only to roll back)	1	21s
			Television -> Light (only to roll back)	1	21s
			* Television -> Leisure (only to roll back)	1	21s
			* Health -> Food	1	21s
			Clothing -> Television	1	21s
			Parent -> Mother	1	21s
			Old_age -> Adolescence	1	21s
			* Leisure -> Television	1	21s
			Water -> Human	1	21s
			* Mother -> Family	1	21s

Appendix R

This table shows heuristically approximated activity frequencies for four collaborator roles of Competing Values Framework in respect to 12 activities that we published in Table 2 of publication [P1] titled "Some approximated relative activity frequencies for each collaborator role". Please note that in later additional experiments we empirically gained activity frequencies for these activities as show in Table 4.3 in Chapter 4 of current publication and we suggest giving specific attention to those empirically gained values.

Activity	*Create role*	*Compete role*	*Control role*	*Collaborate role*
Submits ideas	0.40	0.10	0.20	0.30
Adds nodes to concept map	0.40	0.30	0.10	0.20
Adds arcs to concept map	0.20	0.10	0.30	0.40
Makes references to ideas	0.30	0.10	0.40	0.20
Makes references to concept map	0.10	0.30	0.20	0.40
Comments ideas	0.10	0.20	0.40	0.30
Comments concept map	0.30	0.40	0.10	0.20
Sends coordination messages	0.10	0.40	0.20	0.30
Synthesizes ideas to concept map	0.20	0.10	0.40	0.30
Distributes topics from concept map to reconsideration	0.10	0.20	0.30	0.40
Explores accordance of ideas and concept map	0.40	0.30	0.20	0.10
Requests stimulation for creative thinking	0.10	0.40	0.30	0.20

Appendix T

After publication of the publication [P1] we carried out empirical experiments of collaborative concept map construction process in small groups containing persons having ages in range of 15-18 years and representing four collaborator roles of Competing Values Framework ((Quinn et al. 1990, especially table 1.2 on page 21); (Quinn et al. 1996, especially table 1.2 on pages 23-24)). Before introducing collaborative concept map construction process to the student, we identified for each student which of four major collaborator roles (shown in Table 4.3 (originally published as Table 2 in publication [P1])) he represents by a questionaire that is shown here in this Appendix T. Without revealing in advance what is the purpose of the questionnaire we asked the student to fill in this competing values self-assessment questionnaire that is adapted from Quinn et al. ((Quinn et al. 1990, especially table 1.2 on page 21); (Quinn et al. 1996, especially table 1.2 on pages 23-24)) and among the six sets of four questions corresponding to each four major collaborator roles the one which recieved highest number of points was selected as the role of the student for collaborative concept map construction process in small groups. In the questionnaire questions 1-6 concern having characteristics of innovator-broker role, then questions 7-12 producer-director role, next questions 13-18 coordinator-monitor role and finally then questions 19-24 facilitator-mentor role. We present here both English version and Finnish version of questionnaire that we used with students (Finnish version translated from English version by Lauri Lahti).

English version of questionnaire:

First name:_____ Last name:_____ Year of birth:_____

All these questions ask about how you work as a member in a group.
Please think about what is your role/position when working in a group of people.
For example, think about how you feel/behave when you have to work in a student group at school or when you are doing something together with your friends.

Here you have 24 statements. Please answer how much you agree or disagree with each statement.
Select one number (1, 2, 3, 4 or 5) that corresponds to your opinion:
1 = "I strongly AGREE", 2="I quite much AGREE", 3="Neutral opinion",
4 ="I quite much DISAGREE", 5 = "I strongly DISAGREE"

"When I work as a member in a group…"	☺				☹
1) …I am flexible to tolerate changes.	1	2	3	4	5
2) …I am actively thinking creatively.	1	2	3	4	5
3) …I am active to create changes.	1	2	3	4	5
4) …I am active in building and keeping power structures in the group.	1	2	3	4	5
5) …I am active to negotiate (talk) to reach agreement and commitment.	1	2	3	4	5
6) …I am actively presenting (telling) new ideas to other people.	1	2	3	4	5
7) …I make big efforts to get people working productively.	1	2	3	4	5
8) …I actively try to make working environment productive.	1	2	3	4	5
9) …I am actively thinking how to use time well.	1	2	3	4	5
10) …I am actively planning and setting goals (targets).	1	2	3	4	5
11) …I am actively designing and organizing things.	1	2	3	4	5
12) …I am efficient in delegating (sharing) work to other people.	1	2	3	4	5
13) …I am actively thinking how people can best work together.	1	2	3	4	5
14) …I am actively designing how work should be done.	1	2	3	4	5
15) …I am actively thinking many different things that belong to current work.	1	2	3	4	5
16) …I am actively giving attention to my personal performance in group.	1	2	3	4	5
17) …I am actively giving attention to the performance of the whole group altogether.	1	2	3	4	5
18) …I am actively giving attention to the performance of each individual person in the group.	1	2	3	4	5
19) …I am actively building (forming) groups and teams.	1	2	3	4	5
20) …I actively want to make decisions so that all people in group can agree.	1	2	3	4	5
21) …I make big efforts to help people to avoid conflicts in group.	1	2	3	4	5
22) …I actively understand well myself and other people.	1	2	3	4	5
23) …I actively want to communicate effectively.	1	2	3	4	5
24) …I actively want to give guidance to other people.	1	2	3	4	5

Finnish version of questionnaire:

Etunimi: _____ Sukunimi: _____ Syntymävuosi: _____

Kaikki nämä kysymykset käsittelevät sitä, miten sinä työskentelet ryhmän jäsenenä.
Ajattele, millainen rooli/asema sinulla on, kun työskentelet ihmisten muodostamassa ryhmässä.
Esimerkiksi ajattele, millaisia ovat tunnemuksesi/käyttäytymisesi, kun sinun täytyy työskennellä opiskelijaryhmässä koulussa tai kun olet tekemässä jotain yhdessä ystäviesi kanssa.

Tässä sinulla on 24 väittämää. Vastaa, kuinka paljon olet samaa tai eri mieltä kustakin väittämästä.
Valitse yksi numero (1, 2, 3, 4 tai 5), joka täsmää sinun mielipiteeseesi:
1 = "Olen vahvasti SAMAA mieltä", 2 = "Olen melko paljon SAMAA mieltä", 3 = "Neutraali mielipide", 4 = "Olen melko paljon ERI mieltä", 5 = "Olen vahvasti ERI mieltä"

"Kun työskentelen ryhmän jäsenenä, ..."	☺				☹
1) ...olen joustava sietämään muutoksia.	1	2	3	4	5
2) ...olen ahkera ajattelemaan luovasti.	1	2	3	4	5
3) ...olen ahkera luomaan muutoksia.	1	2	3	4	5
4) ...olen ahkera rakentamaan ja ylläpitämään valtarakenteita ryhmässä.	1	2	3	4	5
5) ...olen ahkera neuvottelemaan (puhumaan), jotta yhteisymmärrys ja omistautuminen voitaisiin saavuttaa.	1	2	3	4	5
6) ...olen ahkera esittelemään (kertomaan) uusia ajatuksia toisille ihmisille.	1	2	3	4	5
7) ...teen suuria ponnisteluja, jotta saisin ihmiset työskentelemään tuottavasti.	1	2	3	4	5
8) ...yritän ahkerasti tehdä työskentely-ympäristöstä tuottavan.	1	2	3	4	5
9) ...ajattelen ahkerasti, kuinka ajan voisi käyttää hyvin.	1	2	3	4	5
10) ...olen ahkera laatimaan aikatauluja ja asettamaan tavoitteita (päämääriä).	1	2	3	4	5
11) ...olen ahkera suunnittelemaan ja järjestämään asioita.	1	2	3	4	5
12) ...olen ahkera välittämään (jakamaan) työtä toisille ihmisille.	1	2	3	4	5
13) ...olen ahkera ajattelemaan, kuinka ihmiset voisivat parhaiten työskennellä yhdessä.	1	2	3	4	5
14) ...olen ahkera suunnittelemaan, miten työ pitäisi tehdä.	1	2	3	4	5
15) ...olen ahkera ajattelemaan useita eri asioita, jotka kuuluvat senhetkiseen työhön.	1	2	3	4	5
16) ...olen ahkera kiinnittämään huomiota henkilökohtaiseen suoritukseeni ryhmässä..	1	2	3	4	5
17) ...olen ahkera kiinnittämään huomiota koko ryhmän suoritukseen yhdessä.	1	2	3	4	5
18) ...olen ahkera kiinnittämään huomiota jokaisen yksittäisen henkilön suoritukseen ryhmässä.	1	2	3	4	5
19) ...olen ahkera rakentamaan (muodostamaan) ryhmiä ja joukkueita.	1	2	3	4	5
20) ...haluan ahkerasti tehdä ratkaisuja niin, että kaikki ihmiset ryhmässä voivat olla samaa mieltä.	1	2	3	4	5
21) ...teen suuria ponnisteluja auttaakseni ihmisiä välttämään ristiriitoja ryhmässä.	1	2	3	4	5
22) ...olen ahkera ymmärtämään hyvin itseäni ja muita ihmisiä.	1	2	3	4	5
23) ...haluan ahkerasti viestiä tavalla, joka vaikuttaa.	1	2	3	4	5
24) ...haluan ahkerasti antaa opastusta toisille ihmisille.	1	2	3	4	5