ACCOMODATING INDIVIDUAL DIFFERENCES IN GROUP FORMATION FOR COLLABORATIVE CONCEPT MAPPING

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Abstract. In this paper we investigate the influence of individual differences in group formation for collaborative concept mapping tasks. The presented pilot study involved 21 students who constructed individual and group concept maps on the central concept "Computer Storage Units". Students were intentionally placed into groups based on their learning-style type; the Honey and Mumford style categorization and the visual/verbal dimension of Felder-Silverman model was used. Various combinations of groupings in terms of learning-style type and level of knowledge, were resulted. Data analysis focused on the influence of learning styles on learning effectiveness in terms of the level of individual learning, the level of collaborative learning and the level of interaction between individual and group. Results provided evidence about efficient grouping approaches, such as group formation based on (a) a mixture of Honey and Mumford learning styles including cases with an average preference on the four styles or a strong preference on particular styles, (b) a mixture of visual levels referring to the visual/verbal dimension, and (c) high or a mixture of knowledge levels. Moreover, evidence about the influence of both the visual/verbal dimension and knowledge level in group-interaction dynamics, was also provided.

1 Introduction

Concept mapping (CM) is one of the most useful cognitive strategies, with a strong theoretical and research background, which stimulates learners to articulate and synthesize their actual states of knowledge during the learning process (Jonassen, 1992). One of the most promising applications of concept mapping is its integration into collaborative learning activities, as research showed that with collaborative effort students could elaborate, refine, and improve their own knowledge structures. Stoyanova & Kommers (2002) investigated the learning effectiveness of CM for computer-supported collaborative problem-solving. They showed that shared cognition, when all members of a group collaboratively construct a map, is more effective than moderated and distributed collaboration.

Computers as well as Information and Communication Technology (ICT) has been used to support collaborative CM since the mid-1990s (Cañas et al., 2001). Nowadays, there is a trend towards the development of web-based tools with collaborative facilities and current focus of research is on the development of web-based CM environments with synchronous and asynchronous communicative facilities (Cañas et al., 2001; Luckie et al., 2004). To this direction, the development of web-based CM environments needs to initially investigate the various aspects of collaboration. An important issue to consider is group formation, that is the grouping of learners with respect to their individual differences, aiming to promote effective collaboration in the context of a concept mapping activity.

In this paper we present a pilot study conducted to investigate group formation for collaborative concept mapping activities, accommodating learners' individual differences in terms of their learning styles and knowledge level. The aim is to provide evidence about how to form efficient groups when the learning style and the knowledge level of the students are known. This study is the first step towards the development of an automatic group formation tool, which will be incorporated in the web-enabled CM learning environment COMPASS (COncept MaP ASSessment & learning environment) (http://hermes.di.uoa.gr/compass) (Gouli et al., 2004). COMPASS serves assessment and learning by employing a variety of concept mapping activities, applying a scheme for the qualitative and quantitative estimation of learner's knowledge and providing different informative, tutoring and reflective feedback components, tailored to learners' individual characteristics and needs.

2 Group Formation of Students

Student learning differs as students differ in their general skills, aptitudes, and preferences for processing information (Jonassen & Grabowski, 1993). In particular, learning styles are related to mental abilities because most of us prefer to use the mental abilities and cognitive controls and styles with which we are more skilled and familiar.

Moreover, the nature of the thinking and learning processes varies with the task. In our case, the task that learners need to collaboratively undertake is the construction of a concept map. We decided to investigate the influence of two learning styles categorizations in students' learning and collaboration: (a) the Honey and Mumford (1992) style categorization as it concentrates on how people learn and deals with the social dimension of learning, as well as (b) the visual/verbal dimension of Felder-Silverman (1988) model mainly because of the nature of the concept mapping task – learners need to graphically organize and relate concepts in a map.

Honey and Mumford (1992, p. 1) define a learning style as being "a description of the attitudes and behaviour, which determine an individual's preferred way of learning". Based on Kolb's learning cycle, Honey and Mumford built a typology of Learning Styles, identifying individual learning preferences for each stage of the learning cycle. The four learning styles are described as those of Activists (gregarious, seek challenge and immediate experience), Reflectors (gather data, ponder and analyse, delay reaching conclusions, listen before speaking), Theorists (think things through in logical steps, assimilate disparate facts into coherent theories, rationally objective) and Pragmatists (seek and try out new ideas, practical, enjoy problem solving and decision-making quickly). Students, during the study, responded to the 80-item Honey and Mumford Learning Styles Questionnaire (LSQ) (1992), which determine preferences with regard to learning. Students were characterised based on their strong preferences (if any) on the different styles and not based on their max value on one of the styles. Thus, a student may be categorized as Activist, Reflector, Theorist, Pragmatist, or combinations such as Activist-Reflector or average on the four styles. This way, we aim to avoid the "danger of labelling people as 'Theorists' or 'Pragmatists', when most people exhibit more than one strong preference (Coffield et al., 2004). The Felder-Silverman model (1988) has four independent dimensions: the sensing/intuitive, the active/reflective, the visual/verbal and the sequential/global dimension. Particularly, the visual/verbal dimension describes the extent to which an individual favours information conveyed as images or as text. The Index of Learning Styles (ILS) questionnaire (1999) (44 items) was used to assess the style of each participant according to the visual/verbal dimension of the Felder-Silverman model. In particular, we acknowledge levels of the visual/verbal dimension, i.e. a student may be characterized as high/average/low visualiser/verbaliser.

Rational for Groupings. To understand the influences of learning styles, students were intentionally placed into groups based on their learning-style type. The knowledge level of the students was not taken into account in the group formation process. However, various combinations of learning-style type and level of knowledge (students' knowledge level was evaluated in the course of the study through their individual maps) groupings were constructed. Another aspect of our study centered on the dynamics of the interactions between students within the groups. It was assumed that the influence of a group member on the final product of the group depends on the learning style type and the knowledge level of the individual.

Groups	Students	H&M	Visual/ Verbal	Groups	Students	H&M	Visual/ Verbal
	Student1	Average Values	Low Visualiser		Student1	Reflector	Low Visualiser
Group A	Student2	Average Values	Low Visualiser	Group E	Student2	Reflector	High Visualiser
	Student3	Average Values	Low Visualiser		Student3	Reflector	Low Verbaliser
	Student1	Average Values	Medium Visualiser		Student1	Activist	High Visualiser
Group B	Student2	Average Values	Low Visualiser	Group F	Student2	Reflector	High Visualiser
	Student3	Average Values	High Visualiser		Student3	Theorist	Medium Visualiser
	Student1	Activist	Medium Visualiser		Student1	Activist-Pragmatist	High Visualiser
Group C	Student2	Reflector	Medium Visualiser	Group G	Student2	Reflector-Theorist	Medium Visualiser
	Student3	Activist	Medium Visualiser		Student3	Activist	Medium Visualiser
	Student1	Max Values	Low Verbaliser				
Group D	Student2	Max Values	High Visualiser				
	Student3	Min Values	Medium Visualiser				

Table 1: Groupings of students.

Groupings of Students. The following groupings (Table 1) were intentionally made to create a combination of similar and dissimilar learning styles following Honey and Mumford's categorization (H&M) and/or the visual/verbal dimension of the Felder-Silverman model (F&S). Group A was comprised of students with average preferences on the H&M styles, and low visualisers. Group B was comprised of students with average preferences on the H&M styles and with varying visual levels. The students of Group C had varying H&M learning styles (2 Activists and 1 Reflectors) with an average visual level. Group D was comprised of students with a range of styles (2 having max values and 1 min values at the H&M learning style categories), with varying visual/verbal styles (1 high and 1 medium visualiser, 1 low verbaliser). Group E was comprised of Reflectors, with varying visual/verbal styles (1 high and 1 low Visualiser, 1 low Verbaliser). The students of Group F had varying H&M learning styles (1 Activist, 1 Reflector, 1 Theorist), with high visual levels (2 high and 1 medium Visualiser). The students of Group G had varying H&M styles (1 Activist-Pragmatist, 1 Reflector-Theorist, 1 Activist), with medium/high visual levels.

3 Design of the Study

Research Questions. There were two research questions guiding the study. The first was "What are the effects of learning style on students' group concept maps". The second research question was "How the learning style and knowledge of an individual influence the group concept maps and the group-interaction dynamics in terms of how s/he influences the final product?".

Method. Twenty-one 4th year undergraduate students, enrolled in a semester-long course entitled "Didactics of Informatics" at the Department of Informatics and Communications, University of Athens, participated in this study. The 21 students were placed in seven groups (three students per group) (see section 2 for students' grouping). Students were asked to complete the LSQ and ILS learning style questionnaires outside of class. As an in-class activity during the session, students were given an individual concept map assignment; students were quite familiar with the concept mapping technique as during the course they had worked on several concept mapping activities. They were asked to act as tutors preparing a concept map using the COMPASS environment (free construction task, that is students are free to choose the concepts included in their maps) concerning the central concept "Computer Storage Units" for a high school class – a topic quite familiar to 4th year undergraduate students. This map would be used as a didactical tool during the corresponding course. According to the provided scenario, tutors should use as a resource the corresponding unit of the course book and take into consideration: the duration of the particular course (30 minutes), the knowledge level (average), age (13-14 years old) and prior knowledge of the students attending the course. Figure 1 presents an individual concept map. Then, students organized in groups and collaborated in constructing the group concept map for the particular concept. In this case, students were asked to act as tutors and collaborate with their colleagues for the same target. For the group map construction, students used COMPASS and consulted their individual concept maps constructed previously. Figure 2 presents a group concept map.

Level 1: Learning effectiveness at the individual level: Level of Individual Learning

- 1.1 Individual Achievement:
  - 1.1.1 Number of correct beliefs (i.e. simple propositions & crosslinks) represented on individual concept map
  - 1.1.2 Number of incorrect/false beliefs or unlabeled links or beliefs that are not able to be assessed, represented on individual concept map
  - 1.1.3 Number of significant beliefs represented on individual concept map (significant beliefs are the correct or part of the correct beliefs according to the aims of the concept mapping task)

Level 2: Learning effectiveness at the level of the group: Level of Collaborative Learning

- 2.1 Group Achievement:
  - 2.1.1 Number of correct beliefs represented on group concept map
  - 2.1.2 Number of incorrect/false beliefs or unlabeled links or beliefs that are not able to be assessed represented, on group concept map
  - 2.1.3 Number of significant beliefs represented on group concept map
- 2.2 Group Creativity: Number of correct beliefs presented on group concept map that are created in collaboration session

Level 3: Learning effectiveness as an interaction between individual and group achievement: Level of Interaction between Individual and Group

- 3.1 Individual to Group Transfer:
  - 3.1.1 Number of significant beliefs that are transferred from individual to group concept map
  - 3.1.2 Number of non-significant beliefs or false beliefs that are transferred from individual to group concept map
- 3.2 Rejection at Group Level:
  - 3.2.1 Number of correct beliefs that are not transferred to group concept map
  - 3.2.2 Number of significant beliefs that are not transferred to group concept map

Table 2: Levels and sublevels of the learning effectiveness analysis.

3.1 Evaluation Framework

In order to answer the research questions of this study we need to evaluate/analyse the students' individual and group work. To this end, we adopted Stoyanova and Kommers's (2002) and Khamesan and Hammond's (2004) approach, according to which learning effectiveness in collaborative concept mapping tasks may be measured on the basis of three levels: the level of individual learning, the level of collaborative learning and the level of interaction between individual and group. Following this approach, for each level, we used several sublevels aligned with the aims of our study. In Table 2, the levels and sublevels of learning effectiveness analysis are presented.

4 Results and Discussion

Each student constructed an individual concept map (see in Figure 1 the map constructed by Student3 of Group B) and a collaborative concept map with the other group members in the collaborative session (see in Figure 2 the map constructed by Group B), with a total of 7 group concept maps constructed. To answer the first research question "What are the effects of learning style on the students' group concept maps" – the level of individual as well as collaborative learning was evaluated. To answer the second research question "How the learning style or knowledge of an individual influence the group-interaction dynamics in terms of how s/he influences the final product?" - the level of interaction between individual and group was evaluated.

Learning effectiveness at individual level: level of individual learning. Learners' individual achievement was evaluated using three measures: total number of correct beliefs (i.e. propositions), total number of incorrect/false beliefs or unlabeled links/beliefs which could not be assessed, and total number of significant beliefs (see Table 3). The distinction between significant and non-significant beliefs was made as the concept map construction task was free (students could include any concept in their maps) and the scenario of the assignment had a specific target. To this end, as significant beliefs, we consider the propositions that fulfil the aims of the assignment for the central concept "Computer Storage Units", e.g. in Figure 1 both propositions "Magnetic Peripheral Storage Units consist of Zip Drive" and "Magnetic Peripheral Storage Units consist of Hard Disk" are correct whilst the second one is significant as the underlying information is aligned with the learning outcomes of the activity. Students' knowledge level was evaluated assigning weights on the above measures (2, -1, 4) based on the formula given below and assigned to one of the characterizations {Insufficient, Average, Rather Sufficient, Sufficient} (see Table 3):

Knowledge level = (total number of correct beliefs - total number of significant beliefs) * 2 – (total number of incorrect/false beliefs or unlabeled links/beliefs which could not be assessed) * 1 + (total number of significant beliefs) * 4 (1)

As illustrated in Table 3, Student1 of Group A has included in his map 18 correct propositions, whilst 16 of these are also characterized as significant. Also, 2 beliefs represented on his map are false and 6 beliefs were not characterized as the particular links were omitted or/and the meaning of the propositions was vague. Student2 of Group A has included only 6 correct propositions in his map, which are also characterized as significant. Student3 of Group A has included 13 correct propositions in his map, which are also characterized as significant. Also, 7 beliefs were not characterized, as the meaning of the corresponding propositions was vague. Thus, the knowledge level of Student1 (Average) and Student3 (Average) of Group A seems similar and higher than that of Student2 (InSufficient) as they included more correct and significant concepts in their maps.

Learning effectiveness at group level: level of collaborative learning. The first way of measuring learning effectiveness at group level was in terms of the collaborative concept maps constructed, using the measures: *group achievement* (total number of correct beliefs, total number of incorrect/false beliefs or unlabeled links/beliefs which could not be assessed, total number of significant beliefs), and *group creativity* (total number of correct beliefs created during the collaborative session and not presented in either individual concept maps). Group performance was evaluated assigning weights on the above measures (2, -1, 4) based on the abovementioned formula (1).

As illustrated in Table 4, Group A concept map includes 23 correct beliefs and 19 of them are characterized as significant. Also, 3 false beliefs are represented on the map and the meaning of 2 beliefs is vague. During the collaboration session, more correct and significant propositions were constructed compared to the individual maps and 5 new correct beliefs were created (compare data of Student1, 2, 3 of Group A in Table 3 with data of Group A in Table 4). Interestingly, although the concept map constructed by Group F represents the most correct beliefs compared to the other group maps, the performance of Group F is lower than that of Group B. This is due to the number of significant beliefs represented on the map, which is lower and the number of incorrect/false beliefs or unlabeled links/beliefs, which is higher than those of Group B.

Groups	**Students**	**Individual Achievement**			
		Total no of correct beliefs	Total no of incorrect/false beliefs or unlabeled links/beliefs not assessed	Total no of significant beliefs	Knowledge level
Group A	Student1	18	8	16	Ave
	Student2	6	0	6	Ins
	Student3	13	7	13	Ave
Group B	Student1	25	0	25	RSuf
	Student2	27	10	20	RSuf
	Student3	23	0	22	RSuf
Group C	Student1	11	0	10	Ave
	Student2	24	2	22	RSuf
	Student3	40	0	31	Suf
Group D	Student1	29	3	25	RSuf
	Student2	28	2	22	RSuf
	Student3	27	6	22	RSuf
Group E	Student1	33	0	24	RSuf
	Student2	16	3	15	Ave
	Student3	25	3	24	RSuf
Group F	Student1	28	2	12	Ave
	Student2	45	3	37	Suf
	Student3	12	3	12	Ave
Group G	Student1	15	1	14	Ave
	Student2	19	3	19	Ave
	Student3	26	5	20	RSuf

Table 3: Analysis of learning effectiveness at the individual level, where Ins: Insufficient, Ave: Average, RSuf: Rather Sufficient, Suf: Sufficient.

Groups	**Group Achievement**				**Group Creativity**
	Total no of correct beliefs	Total no of incorrect/false beliefs or unlabeled links / beliefs not assessed	Total no of significant beliefs	Group Performance	Total no of correct beliefs in collaboration session
Group A	23	5	19	79	5
Group B	24	1	24	95	6
Group C	21	0	21	84	0
Group D	21	2	19	78	1
Group E	21	3	20	79	2
Group F	27	3	19	89	0
Group G	24	1	18	83	1

Table 4: Analysis of learning effectiveness at the group level.

Three clusters of groups were identified based on group performance: Group B has the highest performance (see in column 5 of Table 4, Performance of Group B is 95), next are Groups F, C, G followed by Groups A, E, D. Group B has the highest performance, while Group D has the lowest. Although Group D has students with high knowledge level (see in Table 1 - all the students of Group D have Rather Sufficient knowledge level), the group performance is the lowest. Moreover, the creativity of Group D is also low. It may be that this group had students with extremely different style characteristics as two of the students have the same H&M learning styles (strong preference on the four styles) but quite different visual/verbal dimension (low verbaliser, high visualiser) whilst the third one had exactly the opposite H&M style (low preference on the four styles) compared to the others. It seems that high divergence of learning styles may difficult the group members in their collaboration.

Both Groups A and E have low performance (as group D). Students of these groups have similar H&M styles as in Group A all students have average preference on the four H&M styles, whilst Group E is a sole-Reflector group.

The similarity of students' H&M styles in both groups may stand as an obstacle for an effective collaboration to take place. Interestingly, Group B that also has students with similar H&M styles (average preference) but a mixture of visual levels and higher knowledge level has a higher performance. This difference between the performance of Groups A and B may be due to the mixture of visual levels and the higher knowledge level of the Group B students.

We should also notice that Groups A and B have the highest levels of group creativity although Group A has low performance. Their common characteristic, i.e. students with average preferences on the four H&M styles, may be an appropriate approach for grouping students based on their H&M style. We also notice that Groups C, F, and G have similar performance and students with a mixture of H&M styles. Among these groups, Group F has the highest performance. The particular group has students with a strong preference on three different H&M styles (1 Activist, 1 Reflector, 1 Theorist) and higher visual levels compared to Groups C and G. It may be that such a mixture of H&M styles combined with a mixture of visual levels and knowledge level is an effective approach for grouping students.

Learning effectiveness at group level: level of interaction between individual and group. The second way of measuring learning effectiveness at group level was in terms of the interaction between group and individual concept maps, with two measures of *individual to group transfer* (total number of significant beliefs transferred from individual to group map, total number of false or non-significant beliefs transferred from individual to group map) and *rejection at group level* (total number of correct beliefs not transferred to group map, total number of significant beliefs not transferred to group map). Thus, as illustrated in Table 5, the analysis of the interaction between individual to group achievement indicates that for Group A, Student1 (74%) and Student3 (53%) influenced mainly the group map as the number of significant beliefs that were transferred from their individual to group map was 14 and 10 (out of 19 – see *Total no of significant beliefs* of Group A in Table 4) respectively.

Groups	Students	Individual to Group Transfer		Rejection at Group Level	
		Total no of significant beliefs transferred from individual to group map	Total no of false or non-significant beliefs transferred from individual to group map	Total no of correct beliefs not transferred to group map	No of significant beliefs not transferred to group map
Group A	Student1	14 (74%)	1	4	2
	Student2	0 (0%)	0	6	6
	Student3	10 (53%)	2	3	3
Group B	Student1	14 (58%)	0	11	11
	Student2	11 (46%)	1	16	9
	Student3	18 (75%)	0	5	4
Group C	Student1	10 (48%)	0	1	0
	Student2	13 (62%)	0	11	9
	Student3	19 (90%)	0	21	12
Group D	Student1	9 (47%)	0	20	16
	Student2	16 (84%)	1	12	6
	Student3	13 (68%)	3	14	9
Group E	Student1	12 (60%)	0	21	12
	Student2	14 (70%)	4	1	1
	Student3	12 (60%)	0	13	12
Group F	Student1	12 (63%)	10	8	0
	Student2	18(95%)	3	25	19
	Student3	10 (53%)	0	2	2
Group G	Student1	14 (78%)	1	0	0
	Student2	12 (67%)	0	7	7
	Student3	16 (89%)	5	5	4

Table 5: Analysis of learning effectiveness in terms of the interaction between individual and group achievement.

Student 3 of Group B (see also Figure 1) has the highest impact on the group map (75%), as he transferred 18 significant propositions (out of 24 of Group B – see Table 4) to the group map. Note that, the propositions he transferred were all significant, whilst 5 correct propositions of his individual map were left out with 4 of them being significant (see in Table 3, the *Total no of correct / significant beliefs* of Student3 of Group B: 23/22). Also, Student 3 of Group C has a significant impact on the group map (90%). That student, although he transferred 19 significant propositions of his individual map to the group map, other 12 significant and 9 correct beliefs were left out (see in Table 3, the *Total no of correct / significant beliefs* of Student3 of Group C: 40/31). It is also interesting to note that several students, such as Student2 of Group B (see Figure 2), managed to transfer their individual false beliefs in the group map.

Overall, in many cases learners with the same knowledge seem to influence differently the group map based on their visual/verbal dimension or knowledge level. Thus, students with greater impact on the group map (see Table 5) seem to have the highest visual levels and/or knowledge level. In more detail, in cases were the knowledge level of the students of a group is equal, those with the highest visual level seem to have greater impact on the group map, such as Student 3 in Group B, Student 2 in Group D. It may be that visualisers work better with graphical representations. In cases were the visual/verbal dimension of students is equal or among the students with the highest levels, those with higher knowledge level seem to have greater impact on the group map, such as Student 3 in Group C, Student 2 in Group F, Student 1 in Group A. In Group G where there is a slight difference among the visual/verbal dimension of the three students (2 medium visualisers, 1 high visualiser) and their knowledge level (2 Average, 1 Rather Sufficient); one of the medium visualisers with rather sufficient knowledge level (highest knowledge level among the students of the group) has the greatest impact on the group map. In Group E where the difference of the visual/verbal dimension of the students is great (1 low visualiser, 1 low verbaliser, 1 high visualiser), the high visualiser seems to have a greater impact on the group map although his knowledge level (Average) is lower than the others' (Rather Sufficient). Interestingly, the student with the greatest impact on a group map is a high visualiser with high knowledge level, e.g. see Student2 in Group F who has the greatest impact among all the students (95%) on the group map.

5 Conclusions and Future Research

In this pilot study we investigated the effects of learning style and knowledge level on group concept mapping and group-interaction dynamics. We analysed individual as well as group maps and we provide several data that could serve as valuable indications for accommodating individual differences in group formation especially for collaborative CM tasks. Based on our findings, the ideal group seems to be a mixture of learning styles including cases with average preference on the H&M styles (Group B) or strong preference on different H&M styles (Group F), a mixture of visualisers and knowledge levels. The least ideal group consists of students with extremely different styles or similar styles. Moreover, analysing the interaction between group and individual concept maps we provide evidence about the important influence of both the visual/verbal dimension and knowledge level in group-interaction dynamics. However, this investigation is the first step towards a comprehensive study of the impact of individual differences on group work in the context of web-based collaborative CM systems.

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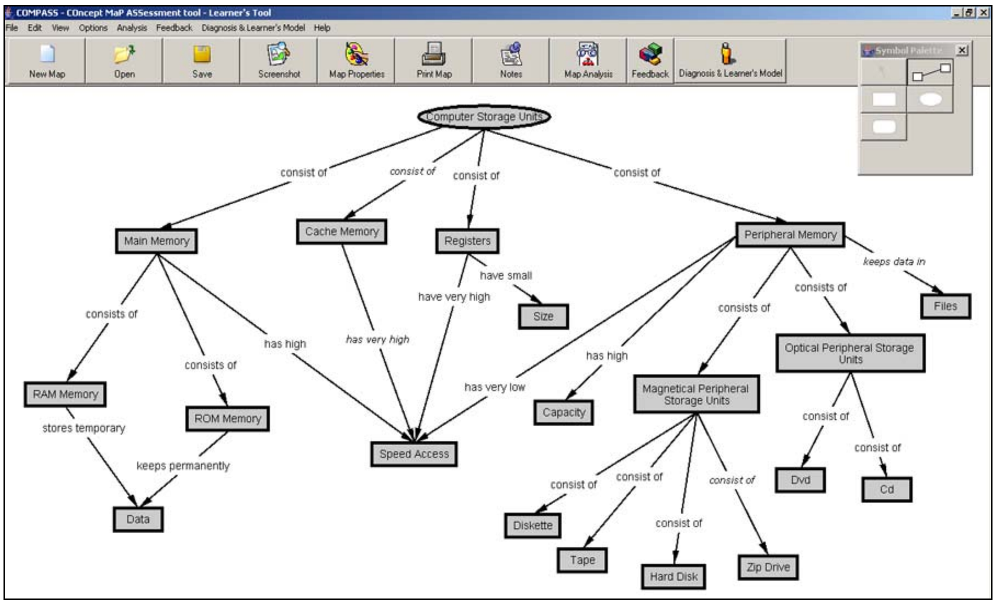

Figure 1. The concept map constructed by Student3 of Group B. It includes 23 correct beliefs with 22 of them characterized as significant. Although Student3 believes that "Computer Storage Units consist of Cache Memory", he didn't transferred it to the group map.

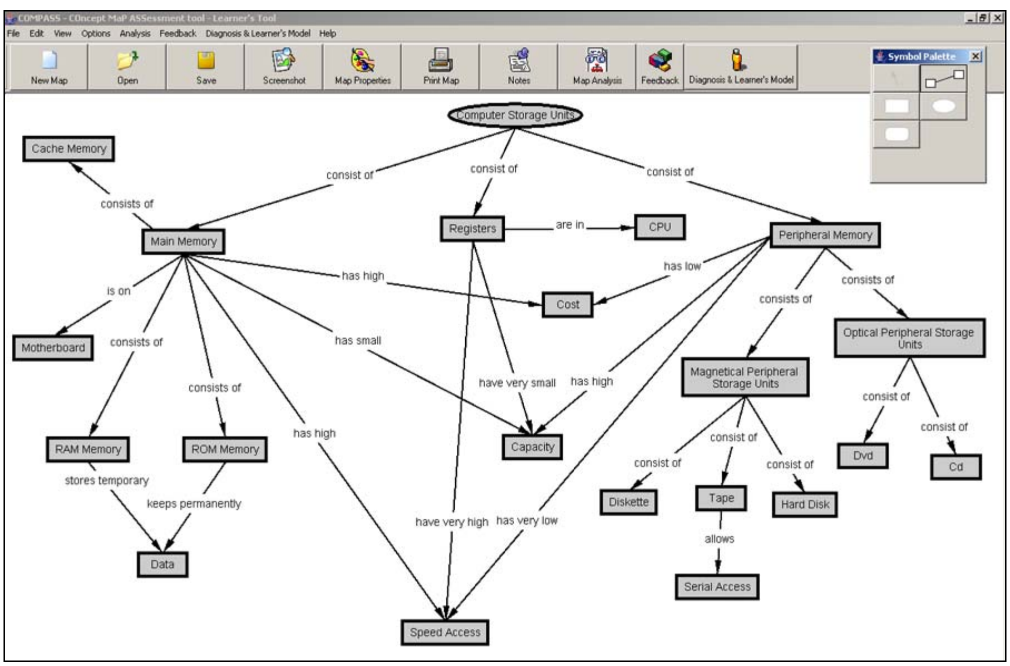

Figure 2. The concept map of Group B: includes 24 significant beliefs and the false belief "Main memory consists of Cache Memory" transferred from Student2's individual map.