Meaningful Learning Forum

Number 1

1996

Introduction

Welcome to the inaugural issue of the Meaningful Learning Forum. This publication is the journal of the Meaningful Learning Research Group, and represents the continuation and expansion of the Misconceptions Proceedings.

We are trying to create a publication which supports the dissemination of, and discussion around, the work of anyone interested in the study and advancement of meaningful learning. At the same time, we are trying to evolve from a single institution research group, to a multi-institution research group that can fully support the work of its members on an international scale.

This first issue grew out of an experimental version of Dr. Joseph Novak's introductory graduate education class at Cornell in the Fall of 1995. This course covered the full range of topics relevant to meaningful learning. One topic which particularly caught the interest of many students was concept mapping. Because of this interest, we decided to focus the first issue of the Meaningful Learning Forum on concept mapping.

Several authors who had contributed to the Third Misconceptions Proceedings responded to our call for articles. Since one of the authors in this issue is the student of a Misconceptions Proceedings author, this issue represents two generations of education scholars. We couldn't ask for a better start.

Marco Moreira and Ileana Maria Greca lead off this issue by describing a study which shows how concept maps relate to the idea of mental models. As a result of the study, they developed a six category system for describing student produced concept maps.

Marli Moreira follows with an article showing how concept maps can relate to students' sense of autonomy. These insights are part of a study which used concept maps to help English as a Foreign Language students understand the plays of Shakespeare.

Zulma Gangoso describes her experience with curricular change. She taught a secondary physics course which utilized concept maps. She constructed a course in which students not only learned physics, but learned about learning theory as well. As one of her students put it, *"..It was important for me that the physics teacher was concerned about how people learn. I think it is true the fact that if you do not want to learn, you do not learn. I learned many things because I was interested in them and I wanted to."(Soledad P.., 16 years old)*

Finally, Kaveh Farrokh and Gerda Krause describe a study in which they looked for a correlation between concept mapping and course grade in a Cell Biology course. They found a moderate correlation, and suggest promising approaches for future studies in this area.

In future issues, we will address other aspects of meaningful learning. Likely topics include other meta-cognitive tools (such as Vee Diagramming), subject area foci, and issues which explore the relationship of meaningful learning to other areas of education (such as emergent literacy and environmental education). We would welcome suggestions for topics which would meet your needs. We will also be experimenting with various forms of editing, such as guest editors, peer review groups, and post-publication peer review and discussion. After all, if we ask students to make a long term commitment to learning, we can ask no less of ourselves.

Sincerely,

Robert Abrams, series editor
Santa Cruz, CA
November 25, 1996

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<u>or to join our group, please write to:</u>
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The Relationship of Concept-mapping and Course Grade in Cell Biology

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ABSTRACT

This study attempted to examine the relationship between concept mapping and course grade in a second year cell biology course at Langara College. After the introduction of the technique of concept mapping in the first session, students were to complete a total of seven maps corresponding to the seven major content areas of the course. Each concept map was constructed in class after the completion of a topic and before advancement into the proceeding topic. Students were allowed 10 minutes to complete a concept map. With an initial sample size of 25 students, 4 withdrew, reducing the number of subjects to N=21. At the completion of the course, all concept maps from all students were collected and rated with respect to number of relevant concepts cited as well as numbers of meaningful semantic connections made. A correlational analysis between course grades and concept mapping scores (number of concepts generated and numbers of meaningful connections made) found a moderate linear (r=.54)

relationship. Observations of the concept maps themselves did show that students with higher marks tended to produce more relevant concepts as well as make more meaningful semantic links between those concepts than students with lower marks. Two students modified their concept maps to resemble diagrams in order to facilitate their learning. The paper ends with suggestions to explore the nature of concept maps incorporating pictures and diagrams. Suggestions for future studies exploring the relationship between concept mapping and course grade include (1) increase in sample size to at least N=30 (2) use of questionnaires and interviews with students in order to record their affective impressions with respect to concept mapping (3) examination of the relationship of concept mapping with other study skills strategies such as time management and the combined effect of these on course achievement.

INTRODUCTION

The use of the concept map is a method of depicting the meaningful relationship between concepts (Novak & Gowin, 1984). It shows the hierarchical relationships of ideas by graphically depicting levels of concepts. It also shows the nature of the relationships between ideas through the use of linking words that connect the concepts. Significantly, concept-mapping offers the student a method by which to unify seemingly disparate pieces of information into a unified whole. Students often complain not only about the amount but of the disparate nature of the information that they must learn. The ultimate aim of concept-mapping is to provide the student with the tools to grasp the meaning of concepts in their courses (in this case cell biology) rather than to simply improve their rote memory skills. Fostering meaningful information and making connections is an intimate part of building declarative knowledge.

Research has been conducted by various researchers with respect to the efficacy of concept-mapping in Biology (Wallace & Mintzes, 1990; Jegede, Alaiyemola & Okebukola, 1990; Sherris & Kahle, 1984). Jegede, Alaiyemola & Okebukola (1990) have found that concept-mapping is significantly more effective in enhancing conceptual understanding than the traditional expository teaching styles of most contemporary Biology classrooms. In addition, it has the interesting effect of reducing students' anxiety towards the learning of Biology (Jegede, Alaiyemola & Okebukola, 1990). Wallace & Mintzes (1990) found that subjects exposed to concept-mapping in Biology showed evidence of substantial changes in the complexity and propositional structure of the knowledge base. As a result of their findings, Wallace & Mintzes concluded that concept-mapping in Biology offers a valid and useful technique for documenting and exploring conceptual change in Biology (1990). A very interesting study by Sherris and Kahle (1984) found that students with an external locus of control benefited more from concept-mapping instruction in Biology than did those who had an internal locus of control.

The effectiveness of concept-mapping lies in its ability to encourage the student to elaborate on the information that he/she endeavors to learn. The process of "elaboration" forces the learner to take an active part in the construction of the information. The principle of elaboration is simply the process of adding to the information being learned, a situation which complements the organization of information (procedures for dividing information into its subsets and indicating the relationships between those subsets). Here is a process in which the student is required to make linkages between concepts and to draw upon information that already exists in his/her long term memory.

Students develop scientific literacy as they understand the key concepts and their interrelationships, and make an effort to apply these understandings to new situations. This type of learning is meaningful learning, as it requires to relate new ideas to existing conceptual knowledge (Ausubel, 1968; Novak, 1993).

In essence, the one aim of concept-mapping in this study is to see whether students become more "expert-like" in the field of cell biology. This concept-mapping process facilitates the learning process of locating interrelationships between concepts as well as helping the student make inferences. Inferences and elaborations can help lay the foundation for the building of a basic declarative knowledge base. Another way of stating this is that the student needs to have a macrostructure(s) that expresses the main ideas of a subject area (Gagne, Yekovich & Yekovich, 1993); in our case topics pertaining to cell biology (i.e. membrane transport, endomembrane system). A declarative knowledge base assists in literal comprehension (putting activated word meanings together to form propositions by using lexical access [meanings of words identified] and parsing [ways that word meanings are combined]). As a result, the student will not get as bogged down in singular isolated concepts as he/she otherwise would without having a declarative foundation.

Note that there are six differences between novices and experts with respect to domain-specific problem solving: (1)size of patterns perceived (2)size of memory (working and long term memory) (3)speed of skill execution (4)depth of problem representation (5)time spent developing a problem representation (6)degree of self-monitoring (Glaser, & Chi, 1988). With respect to *(1)size of patterns perceived*, concept-mapping can assist in organizing information into "maps". These maps allow the student to "chunk" or organize vast groups of information into meaningful groups; a process which helps retrieve more information at the right time (Gagne, Yekovich & Yekovich), 1993). The second item or *size of memory (working and long term memory)*, is related to the first in that more and more information is available as "chunks" when in working memory. With concept-mapping, the information has become more organized in long-term memory; as a result, working memory is not burdened by unorganized details. The third item or *time spent developing a problem representation* is also facilitated by concept-maps in that it allows the student to spend more time in trying to build representations. In a similar vein, Voss & Post (1988) have noted that experts spent close to 1/4 of their solution protocols trying to develop proper problem representation as compared to only 1% of novices! Similarly the fourth item *depth of problem representation* allows the learner to focus more on the bare essentials and not be distracted by salient yet irrelevant details. The expert learner is the one who can focus on the essentials without getting bogged down in details. Concept maps help the location of the main arteries of information. Weiser & Shertz (1983) noted in a computer programming study that experts sort programming problems according to algorithms that can be used to solve them, rather than sorting them by "what they should do" (i.e. novices). Again, as noted in this study, the expert is focusing on the depth of problem representation (i.e. the bare essentials). The final point or *degree of self-monitoring* allows the learner to have more time to check and to see if the concepts "make sense".

Another perspective with respect to concept-mapping is its use in helping build integrated schemas of information. A schema is defined as a form of declarative knowledge which is created by the actions of productions (Gagne, Yekovich & Yekovich, 1993). The main aim of this study was to examine students' ability to build schemas using concept maps and to observe their impact on the final course grade in cell biology. This examination draws upon the research findings of Begg, Snider, Foley, & Goddard (1989) as well as Mcdaniel, Ryan & Cunningham (1989) who found that memory for material requiring active construction (generation) on the part of the learner in recalled better in tests. As noted by Begg, Snider, Foley, & Goddard (1989), generating is another way of encoding information.

METHOD

This was a simple correlational study in that the data collected on the concept maps was correlated to the students' final course grade. The subjects were 25 students initially enrolled in the second year cell Biology course. Four of these withdrew from the course, therefore their concept mapping scores were dropped from the correlational analysis. The final sample size was N=21.

Each concept map was marked according to the number of relevant concepts as well as the numbers of meaningful connections made between those concepts. In the former case (concept production) for example, concepts related to lecture on the general characteristics of the cell would be those such as "centriole", or "flagella". In the latter case (semantic linking), simply drawing lines denoting semantic links would not be enough to elicit a score by the rater. Instead, the words on the links were rated as to their ability to link one concept meaningfully to the next. An example of this would be having the concepts of "flagella" and "cilia" both connected via semantic links to the concept of "centriole" by the statement "attached to a polar". Each relevant concept and each meaningful connection were given one mark respectively. There were 7 topics in which concept maps were produced in the semester: Topics 1-2: Introduction to the cell, Topic 3: membrane structure, Topic 4: membrane transport, Topic 5: nucleus, Topic 6: endomembrane system, Topic 7: non-muscular cell movement.

The procedure was to introduce concept-mapping in the first session of the semester to the class. After the introduction to concept mapping in the first session, the students received a key concept list in order to aid their concept mapping. The class was then told to use concept-mapping in order to recall all information they had from past classes with respect to the cell. All concept maps were to be done in class and each student was given a total of 10 minutes. Two weeks later, students were instructed to again recall important details about the cell, this time using more links and explanations between concepts. In Topic 3 (membrane structure), the class generated the concepts together and then did their actual concept mapping separately. After Topic 3, all concept maps were to be devised by having each student generate his/her terms independently. The same procedure was repeated with the cell membrane system and cell movement. In essence, each concept map was produced after the topic had been wholly covered by the instructor, a time frame usually spanning 10-14 days.

In order to run a proper correlational analysis between students scores on the concept maps and their final marks, the researchers were obliged to follow these steps. The College's numerical schema for the correlation analysis was inappropriate since their sequence uses a "0" for the failure mark F. Instead we used the below schema for the numerical interpretation of the marks:

F =1, D- =2, D = 3, D+ =4, C- =5, C =6, C+ =7, B- =8, B =9, B+ =10, A- =11, A =12, A+ =13.

There were seven sets of concept maps corresponding to the seven topics covered in class. For each topic (X), the student with the highest score was ascribed as the top score or 100% for that particular topic. Each student's score for the concept maps pertaining to that particular topic was then divided by the top score:

$$\frac{\text{Student's Score for the concept map on Topic X}}{\text{Top Score for concept map on Topic X}}$$

This was necessary since topics became progressively more difficult, and as a result, students' numbers of connections would vary or even decrease. In addition, as noted above, a reference with respect to a 100% score was needed as a standard of score comparison. As a result, each connection score is a proportional score.

RESULTS

Table 1 shows the students proportion of connections and their final marks. Table 2 exhibits the correlation coefficients with two-tailed significance for the connections (AVSC) and final grades (GRADE). The correlation coefficient between AVSC and GRADE was .54. As is evident, a moderate linear correlation was found between concept mapping and final marks. The coefficient Alpha for the seven "items" (i.e. the seven concept maps) was .93. This shows a high level of reliability for concept mapping. Results in this study indicate that the outcome of final marks have a relationship to concept mapping in cell biology.

Analyses of the concept maps were more revealing. Students with higher marks (students 3, 7, 11, 16) tended to produce more relevant concepts as well as make more meaningful semantic links between concepts than students with lower marks. Two students (students 6, 10) modified their concept maps to resemble diagrams in order to facilitate their learning (see Diagram 1 and 2). Another noted observation was the dramatic increase in numbers of concepts and semantic links for all students in topic 2 as opposed to topic 1. The trend of increase in concepts and semantic links did not present itself with succeeding topics.

DISCUSSION

The most remarkable finding in this study was the moderate correlation between concept map scores and course grades (r=.54). This indicates that an increase in final mark is associated with a corresponding increase in concept map scores. In addition, a number of useful observations did emerge from this study. A few students integrated pictures and diagrams with concepts and semantic links in order to obtain a more three-dimensional view of the information (see Diagram 1 and 2). Future studies may explore the relationship between the use of more "creative" concept maps (those that incorporate pictorial information with the traditional techniques of concept mapping) and course grade.

The trend in the increase in concepts and semantic links from topics 1 to topic 2 can be explained by the fact that both covered the same topic "introduction to the cell". In essence, topic 2 was a review of topic 1; the increase in performance can be explained by the practice effect of having produced the same concept map two weeks before. The numbers of concepts and semantic links produced were to fluctuate randomly from topic to topic and from student to student. Of course, this may be partially explained by the fact that the topic became increasingly more difficult as the course progressed.

Future studies of the concept mapping and course grade relationship may benefit from (1) increase in sample size to at least N=30 (2) the use of questionnaires and interviews with students in order to record to their affective impressions with respect to concept mapping and (3) the examination of the relationship of concept mapping with other study skills strategies such as time management and the combined effect of these on course achievement. Each point is briefly addressed below.

(1) *increase in sample size to at least N=30*: It is acknowledged that this study lacked the sample size needed to carry out further rigorous statistical analyses. In order to observe the impact of small sample size, it's necessary to look at the concepts of the sampling distribution of the mean as well as the central limit theorem. The Sampling distribution of the mean is a theoretical distribution consisting of the mean scores of all possible samples of a given size from a population (Jaccard, 1983). Howell (1992) sums up the salient information about the sampling distribution of the mean into the central limit theorem. The central limit theorem states that as a given a population with mean μ and variance σ^2, the sampling distribution of the mean will have a mean equal to μ, a variance equal to σ^2/N and a standard deviation equal to $\sigma^2/[N]^{1/2}$ (Jaccard, 1983; Howell, 1992). In sum, the sampling distribution approaches the normal distribution as N, provided that our sample size (in this case 26), also increases. Jaccard (1983) and Howell (1992) both recommend sample sizes greater than 30. Our sample size is borderline at best N=21.

(2) *use of questionnaires and interviews with students in order to record their affective impressions with respect to concept mapping*: Jegede, Alaiyemola and Okebukola (1990) found by using the Zuckerman Affect Adjective Checklist that concept mapping reduced students' anxiety towards the learning of biology. Interestingly, this trend was more significant in male subjects (Jegede, Alaiyemola & Okebukola, 1990). This effect may

be explained by the fact that students are given another "tool" with which to control their source of anxiety, which in this case would be the information load in cell biology. The failure rate is high in this course as observed at Langara College. The difficult nature of this course is bound to cause anxiety, however these issues were not addressed in this study. Carrier, Higson, Klimoski and Peterson (1984) have noted that anxiety can have debilitating effects on note taking by interfering with the process of obtaining key words. Another arena worth exploring is the notion of students' locus of control. As noted earlier, Sherris and Kahle (1984) found students with an external locus of control benefiting more from concept-mapping instruction in Biology than did those with an internal locus of control.

(3) *examination of the relationship of concept mapping with other study skills strategies such as time management and the combined effect of these on course achievement*: Techniques such as time management may also play an important role in student success in cell biology. The amount of "raw" time spent studying seems to have no impact on course achievement, course grades and even subsequent recall (Thompson, 1980; Neslon & Leonisio, 1988; Wilhite, 1990). Wilhite (1990) discovered that it is the allocation of study time to specific tasks that meets with success. Also, the better the student's study techniques, the better his/her chances of academic success (Wilhite, 1990). One possible explanation for the apparent lack of impact of concept mapping on course grade may have to do with the fact that students enrolled in cell biology at Langara College may be deficient in study skills such as time management. Langara College's counseling department's workshops for study skills tend to attract far more first year students than second year students (i.e. cell biology). Concept mapping is but one tool of the student's total array of techniques with respect to coping with various course demands. Ultimate success must inevitably depend on the student's ability to combine various tools such as time management and concept mapping in order to maximize chances of academic success.

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Table 1

Student Concept Map Scores (Connections) and Final Course Grades (Grade)

	Connections	Grade
Student 1	.68	6.00
Student 2	.36	1.00
Student 3	.61	10.00
Student 4	.56	1.00
Student 5	.42	6.00
Student 6	.32	7.00
Student 7	.56	10.00
Student 8	.50	7.00
Student 9	.69	7.00
Student 10	.30	5.00
Student 11	.92	10.00
Student 12	.38	7.00
Student 13	.61	5.00
Student 14	.64	5.00
Student 15	.56	5.00
Student 16	.79	10.00
Student 17	.62	5.00
Student 18	.45	6.00
Student 19	.29	1.00
Student 20	.24	3.00
Student 21	.54	3.00

Table 2

Correlation Coefficients of Student Concept Map Scores (AVSC) and Final Course Grades (GRADE)

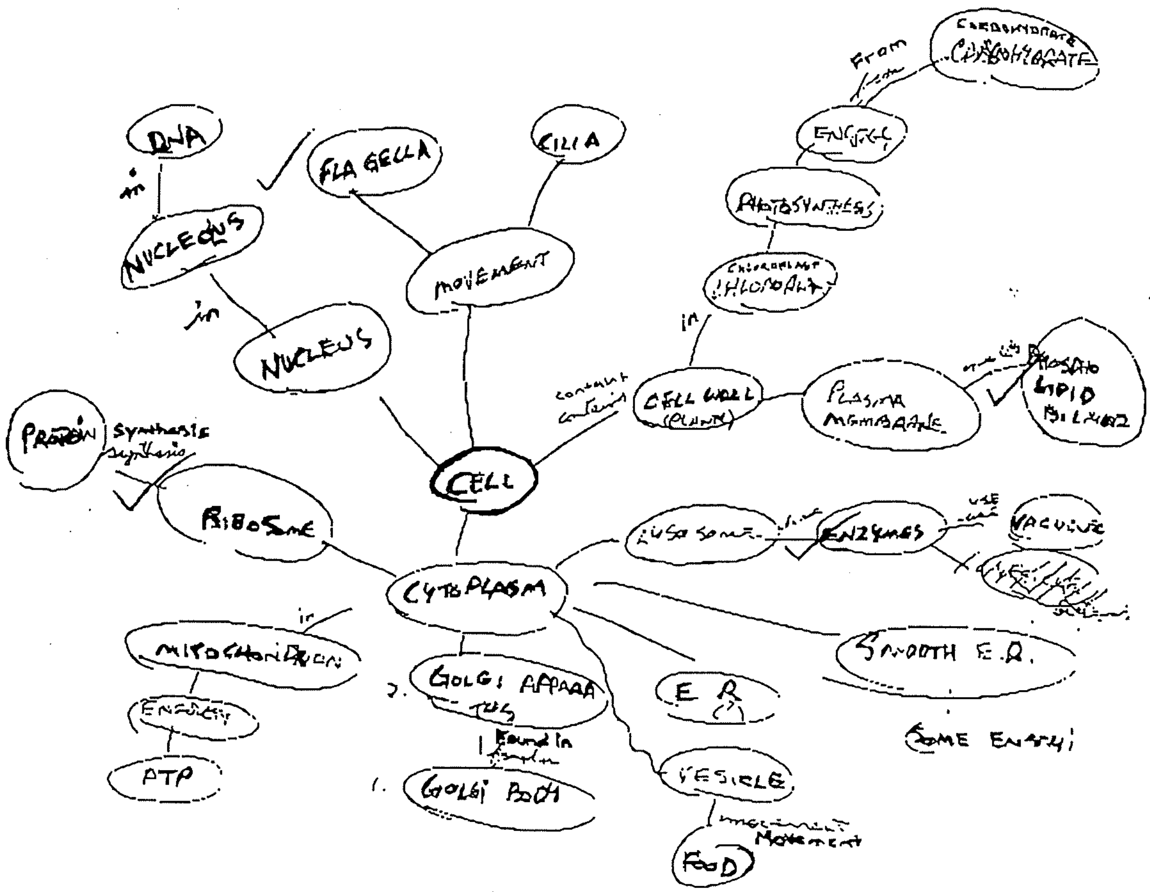
	AVSC	GRADE
AVSC	1.0000 (21) P= .	.5426 (21) **P= .011**
GRADE	.5426 (21) **P= .011**	1.0000 (21) P= .

Diagram 1

<u>Student 10's Concept Map on Topic 1 (Cell Biology)</u>

Diagram 1

Student 10's Concept Map on Topic 1 (Cell Biology)



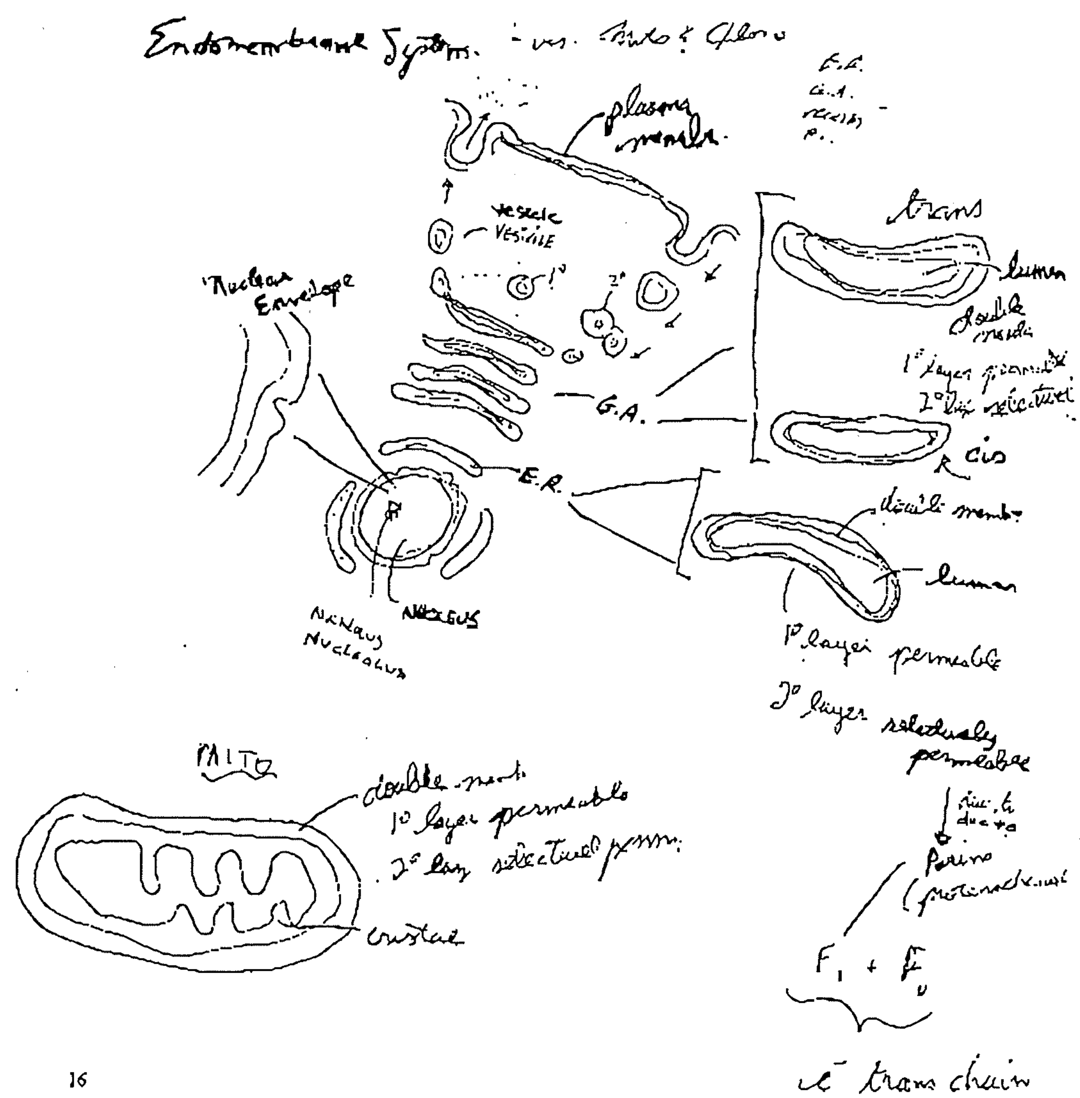
15

Diagram 2

Student 10's Concept Map with diagrams and Pictures on Topic 6 (Endomembrane System)

Diagram 2

Student 10's Concept Map with diagrams and Pictures on Topic 6 (Endomembrane System)



BIOGRAPHY

Kaveh Farrokh: Kaveh graduated with a Master's in Cross-Cultural Psychology in 1988 from the University of British Columbia (UBC. The thesis topic was a joint study with CICA of Canada researching the issue of foreign student personal and academic adjustment to Canadian universities. At present, he is enrolled in the Ph.D. program of Educational Psychology at UBC. He was at Cornell University to present his works in the *Third International Seminar of Human Learning and Memory in August 1993*. These articles dealt with a mathematical model of human memory as well virtual reality technology and education. At present, Kaveh is nearing the completion of two books on learning and memory as well as having a recent publication with Dr. Jackie Baker-Sennett of UBC on the socio-cultural aspects of child language. His previous activities include, two live lecture appearances on learning memory and concept-mapping in the British Columbia television knowledge network program (March, 1988 and March 1989). He has also six years of counseling experience in Langara College which includes duties as an instructor of study skills and memory training. He has produced research manuals and presented them on Langara College professional development sessions on the topics of instruction, study skills and student success and has compiled various other study skills reference materials. His textbook on study skills will be a compilation of all research done in the past five years on study techniques used in all of the major topic areas at Langara College (i.e. Maths, Sciences, Humanities, etc.)

Gerda Krause: Gerda obtained her Master of science at the University of British Columbia's Botany department. Her thesis topic focused on cyto-genetics of natural plant populations. Gerda has been at Langara since 1978. She has taught cell biology, botany as well as general biology. She has been the Biology department chair since 1995. Gerda chaired the Langara Research Committee for 3 years. She also was an active member of the Langara discussion group that focused on learning and problem-solving. She has also been on the Langara professional development committee and the chair of the math-science professional development committee (1988-1994). Gerda has collaborated with Kaveh on research on learning strategies (i.e. concept-mapping) used by students in cell biology. She also has an interest in student attitudes towards science.

---------- Forwarded message ----------
Date: Thu, 29 May 1997 09:34:51 -0400 (EDT)
From: Misconceptions Seminar <miscon_seminar@cornell.edu>
To: kfarrokh@langara.bc.ca
Subject: Paper presentation time

Dear Dr. Farrokh:

Thank you for submitting a paper proposal for the educational symposium "From Misconceptions to Constructed Understanding" being held here at Cornell June 13-15, 1997. Your paper has been scheduled for presentation during the following session time:

Saturday, June 14th, 9:00 am - 10:30 am

Please plan on a 10 to 15 minute presentation to allow time for discussion. We also suggest that you bring 20 copies of your paper for distribution. If there are other authors involved with your paper, please pass this information on to them.

If you have any questions, please do not hesitate to contact us. We look forward to seeing you in June.

Rosemary Hulslander

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