CONTROLLING INFORMATION LOAD THROUGH PRE-LECTURE ASSIGNMENTS AND STUDENTS' ACHIEVEMENT IN MATHEMATICS AT SECONDARY LEVEL

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ABSTRACT

Various studies in the past explored a positive correlation between information load and students' understanding difficulties. In topics where the thought steps exceeded the working memory limit the performance collapsed quite spectacularly. The capacity of this part of the brain is determined genetically fixed. However, the room for efficient use of this part is open largely through experience. In this study pre-learning strategy was practiced to minimize the load on working memory in order to improve students' understanding in mathematics. To follow the strategy, twenty pre-lectures were developed from year 9 and 10 mathematics textbooks followed by twenty post-tests. A sample of 212 students was taken from two FG schools in Peshawar Cantt. The outcome was focused in terms of understanding rather memorization. No changes were made in the curriculum content, time allocation and the teachers. The results depicted significant improvement in students' performance in the stipulated topics. The results are consistent with previous studies in very different contexts, which highlighted significant importance of pre-learning practices.

Keywords: *Information load; Working memory capacity; Understanding difficulties; Pre-lecture; post-test*

Introduction

Mathematics is taught as compulsory subject from grade one to ten in Pakistani schools. Despite the importance, many students don't take interest and perform poorly in this subject (Maduabum and Odili, 2006; Okereke, 2006). To some mathematics' educationists, the main reason behind the complexity is its abstract nature. Due to its intuitive and non-rigorous approach students usually dislike subjects in mathematics (Mushtaq, 2009). Thus it is not surprising that anxiety and fear arise with such views of mathematics-perhaps emotions are being suppressed (Orton, 1992, 2004).

In fact, in mathematics, various underlying abstract ideas consist of symbols, numbers, letters and their combinations. The tasks mainly accomplished at imaginative level which usually pose information load on the learner. Information load is defined as the number of pieces of information which the learner has to hold at the same time in order to

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perform the task successfully (Reid, 2011). The phenomenon of information load is further linked to information processing capacities of the learner. Miller (1956), finding in this regard is definitely a big breakthrough in the field of cognitive psychology.

His finding was the measurement of a key part of the brain later known as working memory. The average adult capacity is 7 pieces of information and most adults possessed a capacity between 6 and 8 (Reid, 2011). Not only could its capacity be measured but it was found to be fixed genetically, growing with age up to age of sixteen (Baddely, 1986). In this part of the brain we do our main cognitive processes such as reasoning, understanding and problem solving. The working memory is the part of brain where information is held temporarily, the information is manipulated, rearranged, brought together, and understood (Reid, 2011; Baddeley, 2002). In the light of information drawn from long term memory thinking and problem solving take place. It is now known that the capacity has to accommodate not only the items of information to be held at the same time but also to have space to carry out the necessary processing of that information (Johnstone, 1997). Therefore due to limited capacity, it is easily overloaded. There is a positive relationship between working memory capacity and information load (Johnstone & El-Banna, 1989).

As Load Increased the Success Rate Dropped Dramatically

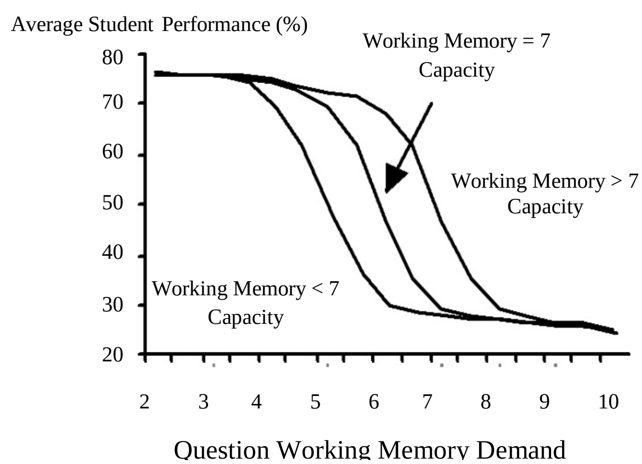

Figure 1. Performance collapse as information load increases Johnstone & El-Banna (1989)

The above figure shows as the information load increased the success rate dropped dramatically. If there is too much to hold, there is not enough space for processing; if a lot of processing is required, we cannot store much (Johnstone et al, 1989).

Understanding requires the young learner to hold too many ideas for their limited working memory (Reid, 2011). The capacity of working memory was found to be fixed genetically (Miller, 1956). So the only workable option i.e. the capacity has to accommodate not only the items of information to be held at the same time but also to have space to carry out the necessary processing of that information (Johnstone, 1997). Therefore concentration should be diverted to this phenomenon. In other words strategies should be adopted to reduce the load on working memory. In this way better results can be expected to improve students' understanding.

Danili & Reid (2004) observed a remarkable improvement in the performance of 15-16 years students in the subject of chemistry, when the material was redesigned. No changes were made to content, time and teachers but the material was designed in the manner to reduce working memory overload by linking the new material with already learned, to encourage understanding and by using relevant applications.

Hussein & Reid (2009) redesigned some large portions of the chemistry curriculum in the way that the working memory demand was lowered. They recorded 13% improvement in students' understanding. Chu (2012) made an experimental study in the field of genetics in Taiwan. By redesigning the material to reduce working memory overload, he found the experimental group performed significantly better than the control group in both school examination and word association test.

A key to focus

The first step in human processing and learning is perception; in other words, what we admit through our senses (Zaman, 1998). Admitting new information to our mind is a selective process (ibid). An expert attends to what is important or of interest or of greater impact, whereas, a novice attends to all the incoming information due to lack of anchoring units of information in the long term memory (ibid). The selection process is driven by the criteria which are already available in the long term memory of the expert. His previous experiences, knowledge, interest and misconceptions control the perception filter (ibid). There are some important predictions from the johnstone (1997) information processing model.

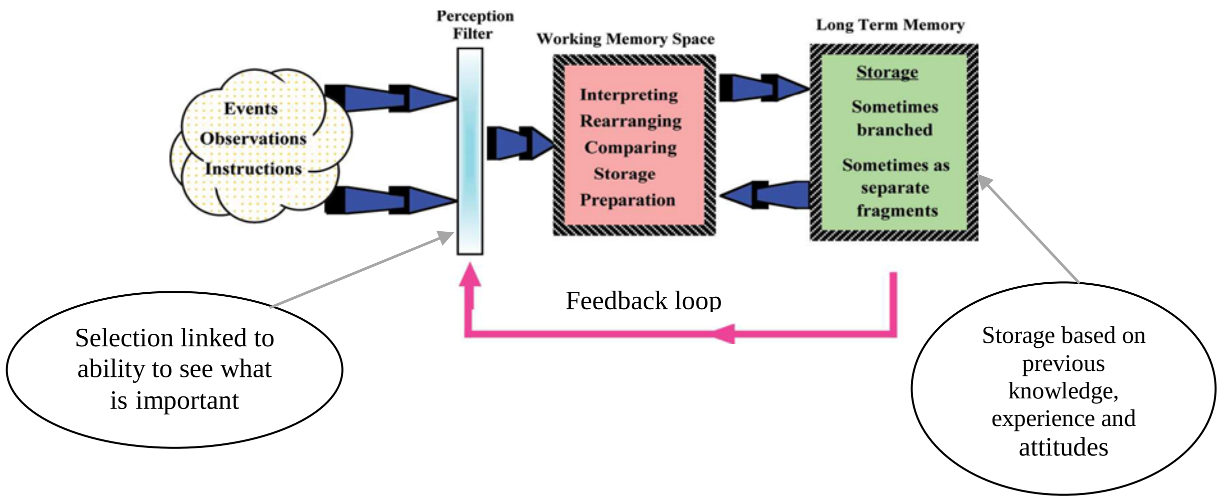

Figure 2. Predictive Model of Learning Science (Information Processing) By Johnstone, 1997, Reid N, 2011.

This model predicts, if the perception filter works efficiently, the working memory overload is less likely. This model also predicts the perception filter is controlled by what is already held in the long term memory. Johnstone (1997) shows that our previous experiences, prejudices, preferences and knowledge control the perception filter.

Mathematics is hierarchical in nature (Gagne, 1965). Each concept based on some pre-requisite sub concepts. For example, to learn the concept of "Rationalization of Binomial Surds" based on two immediate sub concepts such as;

- Conjugate: For example (a-b) is conjugate of (a+b), similarly the conjugate of $3+\sqrt{7}$ is $3-\sqrt{7}$
- How we get difference of two squares $(a-b)(a+b)=a^2-b^2$

In the above case if a learner has no information of the two sub concepts in the long term memory, then, it becomes quite difficult to isolate what is important and what is not needed to be processed further (Alam, 2013). Hence, no doubt attaining all the information at same time leads to working memory overload. Ignoring, what is already there in the mind of the learner may lead to mental overload which ultimately end at rote learning. To follow the same, pre-learning strategy was employed in this study with the assumption to help out the learner to focus on relevant information. Thus, the load on working memory would be reduced. Further, the students' understanding in mathematics would be built up.

Pre-lecture and pre-lab practices were highly effective in building up students' understanding in different subjects at university level (Dawson, 1978; Ebenezer, 1992; Johnstone, 1997a, 1997b; Johnstone *et al*, 1994; Kristine, 1985; Sirhan *et al*, 1999). Pre-lectures activities had greatest benefit for those students who were least well qualified (Sirhan *et. al*, 2001). In statistics the students who prepared pre-lecture quizzes felt better prepared for, and less anxious about, exams and believed that pre-lecture quizzes helped them keep up the course reading (Brown and Sternberg, 2008). In physics at grade 10th level a significant difference was observed between the performance of the students with and without pre-lab (Safdar, 2010; Zaman and Awan, 2006).

Objectives of the Study

The special objective of this study was to design the teaching approach in a manner to reduce information load on working memory through pre-lecture assignments, in order to improve students' learning (in terms of understanding) in mathematics at secondary level.

Research Design and Procedure

In this study pre-lecture post-test randomized experimental group design was used. This design involved two groups .i.e. with pre-lecture and without pre-lecture. The students in first group got instruction through information processing model whereas in the second one through traditional teaching methods. The post-test mean scores of the both groups then analyzed and compared to judge the effectiveness of the treatment. The selection of the groups was made on the basis of their previous results in the subject of mathematics in internal and external Board exams. Besides this an attitudes questionnaire was also administered on the sample before employing research plan. Because research reveal positive correlation exists between the students' attitude and their achievement in mathematics (Farooq and Shah, 2008). Hence, no significant difference was observed between the attitudes of the two groups.

Duration/Data Collection:

The experimentation process was continued approximately for the whole academic session 2011-12.

Sample of the Study:

To assess the impact of pre-lectures developed by the researcher, a sample of 212 students was taken from two Federal Government schools in Peshawar Canntt. There were 114 students from year 10 (78boys and 36 girls). Further they were equally divided into with and without pre-lecture groups. From year 9 there were 98 students, 43 boys (22 with and 21 without) and 55 girls (31 with and 24 without). The students were aged between 14 and 16 years old, belonging to lower middle class civilian and low ranked armed forces families.

Content of the Study:

Twenty topics each from grade 9th and 10th mathematics text books were selected on the pattern of the topic selection criteria duly employed by Federal Board for the annual examinations. For this purpose five years previous papers were thoroughly screened out and finally the topics were selected. In this way the concentration diverted to the key topics of various chapters. Further it was helpful to cover the entire syllabus to a greater extent.

Procedure & Time Table of the Study

The with pre-lecture group got instruction through pre-lecture (information processing model), whereas the without pre-lecture students through traditional teaching method. One week before the scheduled lectures pre-lectures was handed over to former group and they were instructed to complete the preparatory work before coming to the lecture. On the delivery day of the scheduled lectures during the first five minutes of the lecture questions were raised about the preparatory work. After finding the satisfactory answers then progress was made to start the topic. The topic was detailed in accordance with the main headings of the pre-lecture.

On the alternate day of the scheduled lectures, twenty minutes post-test was conducted for both groups. In one of the two sampled schools i.e. in boys section the researcher himself conducted lectures with the boy students. In the girl section there was only one female math teacher responsible to conduct the routine classes at secondary level. She was given two days training prior to implementation of research plan. The regional authority of the schools was taken into confidence and hence found co-operative in this regard.

Instruments

In this study three instruments were used for data collection. The first instrument used in this study was the attitude questionnaire before conducting the experiment. This was to find any difference between the attitude of the sample with and without pre-lecture. The other instrument was pre-lectures handed over to the experimental group time to time in accordance with the scheduled syllabus to be taught. Similarly post-tests were conducted to both the groups in order to find out the effectiveness of the new methodology. The detail of each one is given below;

Attitude Scale

Studies reveal a positive correlation between students' performance and achievement in mathematics. To assess this factor in detail an attitude questionnaire was developed on the five points Likert (1932) format. The questionnaire was composed of 20 items. An attitude scale should yield consistent result (Sommer *et. al*, 1997). Therefore to ensure the reliability, the attitude questionnaire was developed in two parts. The first ten items designed to point towards different competencies in mathematics positively, whereas the other ten items pointing the same in negative form. The second part was constructed to check the consistency of the responses between the positive and negative statements of the attitude questionnaire.

Pre-lecture

The humans are patterns seekers as new things are related into an existing system to make sense of it (Jhonstone, 1997). The new idea is rejected when it doesn't make any sense. In other words the new idea is rejected when there is no relevant idea in the long term memory of the learner. On the basis of relatedness and disconnection there are two extremes to learning, meaningful and rote learning (Ausuble, 1968). Meaningful learning is done when the new knowledge embed into existing one. Rote learning is done when the coming idea finds no link to what is in the mind of the learner.

To establish anchoring ideas in the mind of the learner is an important step, which allows the perception filter works efficiently. Thus, extra load on working memory is reduced, ultimately it leads to understanding. Pre-learning especially in laboratory work showed considerable improvement in students' understanding (Zaman, 1996, 1998; Safdar, 2010). With the above assumptions in the mind, twenty pre-lectures were developed with the assumption to improve understanding. For the background knowledge related to each key topic few questions were included. This was for the purpose to prepare the mind of the learner.

Post-tests

Twenty post-tests each of ten marks were developed by the researcher for the stipulated topics to assess what the students in both groups had learned during the class work. It was assumed that the post-test might have provided a closer overview for the students regarding their performance in the subject of mathematics. It was also assumed that the post-test might have provided the opportunity to the students to draw conclusions, think critically and develop skills in problem solving.

The items in the post-tests were specifically designed to explore higher order thinking skills of the students. For this purpose "post-tests" were prepared keeping in view the cognitive domain of Bloom's Taxonomy. Efforts were made to cover the higher levels such as application, analysis, synthesis and evaluation wherever possible. To a greater extent efforts were made to build up a connection between the concepts of previous topic with the coming topic. It was for the purpose to bring conceptually the students from the frontiers of one topic to the other. Wherever possible consideration was made to incorporate daily life problems to inculcate the students' interest and broaden their concepts in mathematics.

Analysis and Results

The aim of this study was to assess the students' understanding in mathematics at secondary level, when they have been taught with a new teaching approach focusing to minimize working memory overload. The overall performance of the experimental and control groups is compared. There were two phases in this study. The phase-I compares the post-test mean scores of the sample with and without pre-lecture, where as the phase-II compares the mean scores of the said groups in Federal Board Annual Examination (2012). Two students of the without pre-lecture group couldn't appear in Board exam, therefore, the data analysis was confined to the sample of 210 students.

Table 1 shows the performance of the two groups in both phases. An independent samples *t*-test was used to compare the mean scores of the two groups in respective phases.

Table 1:
Post-test data analysis

Phase	Groups	*n*	Means	SD	*t*-value	Probability
I	With	110	5.49	1.19	9.26	$P < 0.001$
	Without	102	3.87	1.35		
II	With	110	52.16	16.78	3.04	$P < 0.01$
	Without	100	44.78	18.36		

The statistical significance appeared as $p < 0.001$ and $P < 0.0$, which clearly indicates that the experimental group performed much better. The results are consistent in very different contexts with the studies of *Johnstone et al, (1994) and (1998), Sirhan & Reid (2001), Zaman (1998), Zaman et al, (2006), Safdar (2010),* who found a remarkable improvement in test performance using pre-lecture assignments, overtly aimed to reduce working memory overload.

Discussion

In this study, no changes were made in the content taught, no extra time was given in teaching. However, the experimental group used pre-lecture assignments. Similarly both groups got instruction from same teachers. The pre-lectures were arranged in a more stepwise fashion. The order of presentation was changed by improving signals such as; what to learn, how to learn and why to learn. The aim was to minimize the demand on working memory. To a greater extent efforts were made to avoid biasness, therefore the indicator of performance was extended to Federal Board Examinations. However, the main indicator of performance (in terms of understanding) was the post-tests, developed by the researcher. Because in Pakistan the school as well as Boards examinations systems measure learning at lower cognitive levels mainly recall *(Bashir 2002, Shah and Afzaal 2004)*. Therefore the use of new teaching approach in this context is of less value.

Conclusion

The new teaching approach used in this study improved students' understanding in mathematics at secondary level as indicated by post-tests. The Phase-II results show an increase in performance of both groups in the Board Examination as indicated through lower *t* values occasionally not significant. This confirms that Board Examination mainly measure learning at lower cognitive levels such as procedure and recall. Hence, it confirms consistency with *Bashir (2002) and Shah & Afzaal (2004)* studies. Moreover the results are consistent with a similar study of *Safdar (2010)* in the subject of Physics theory and practical, who found an increase in performances of the two groups in Board Examination with lower *t* values. As whole the students with pre-lecture performed significantly better than the students without pr-lecture. Further it can be concluded that the new method aided to the recall of the students.

This study indicates that reducing working memory demand through pre-lecture assignments lead to understanding. The approach used in this study is helpful to guide the students at higher cognitive levels, which further lead them towards problem solving capabilities. Moreover it can be concluded that poor curriculum and poor learning experiences affect drastically students' understanding in mathematics.

Recommendations

The school administrators of the population concerned are suggested to stress understanding rather than recall. This study has explored, the same can be achieved while keeping in view the information load and students' working memory limitations. This study also explored that the mathematics text-books has a lot of noises in the content. In this way a lot of effort is required by the concern authorities to make arrangements in order to set the textbooks in accordance with the psychology of the learners. The Federal Board authorities are recommended to take steps to discourage rote learning by making changes in examination system especially in paper pattern of mathematics to assess students' achievement at higher cognitive levels. This study may be conducted in other science subjects at secondary level and other parts of Pakistan to find out the effectiveness of pre-lecture practices on students' understanding.

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