

MUSICAL MNEMONICS TO FACILITATE LEARNING OF TRANSCRIPTION OF RNA

Miranda P. Yeoh

Kolej Matrikulasi Selangor
Kementerian Pendidikan Malaysia
<miranda@kms.matrik.edu.my>

Abstract

Malaysian students need to be skilful in both English and Malay in this global era. Matriculation students learn Biology in English, and they have difficulty in remembering the facts. Musical mnemonics were used to enable the students remember the facts of the process of Transcription of RNA correctly; and in the right order. The medians for the experimental group and control group were 10.0 and 4.0 respectively. Mann-Whitney test showed a significant effect was produced by the teaching approach; $W(76) = 780$, $Z = -8.066$, $p = .0005$. Based on the findings, the researcher suggests that musical mnemonics should be used to facilitate recall of other biological processes. As a learning tool, musical mnemonics must meet several criteria in order to be effective, and the researcher has suggested the criteria. The results of this study imply that, with some innovations, Biology can be successfully learned in English.

Keywords: Transcription, RNA; Messenger RNA; Protein synthesis; Procedural knowledge; Musical mnemonics; Modelling

Introduction

Our knowledge is stored and encoded in our brain as ‘constructs’. New information is understood only when it is connected to existing concepts, knowledge and experience. Hence, new information is linked to existing knowledge by the learner to form new knowledge, and this process is constructivism. The links are stronger if they involve recent vivid, multisensory experiences, encountered in the learning process (Petty, 2009). In this study, musical mnemonics is the learning tool to engage learners with a song, and to enhance memory recall (Cirigliano, 2013; Miendlarzewska & Trost, 2014).

A second aspect is that learning facts or declarative knowledge is different from learning how to do something or procedural knowledge (Michael, 2006). Transcription of RNA (ribonucleic acid) is a topic requiring both declarative and procedural knowledge. The students have to remember the facts; besides that, they must remember the order in which the processes occur. The sequence must be correct. This makes it more difficult to master biological or biochemical processes that require both declarative and procedural knowledge.

A third aspect concerning learning is that people learn through observing and imitating other people’s behaviour and attitudes. This is explained in the Social Learning Theory. Just as children watch and imitate parents, students watch, and imitate the behaviour of teachers that will enable them to achieve their learning objective. This is observational learning or modelling (Bandura, 1977; Yeoh, 2013c). The students observed and followed the researcher in drawing three diagrams for Transcription from the information contained in the mnemonics. This process required about 30 minutes.

Background and Purpose

The students of Matriculation Colleges learn Biology in English; all the sciences are taught and tested in English. Matriculation colleges continue to teach Science and Mathematics in English to prepare students for universities. But English is not the first language of the majority of students. Students had said that they are able to understand the processes or steps of Transcription. The researcher observed that the students were able to answer the structured and essay questions in the Biology tutorial book. They had prepared answers to the questions before the tutorial class. But they said that they were not sure how well they could remember when there were many more new chapters to be learned within the semester. Transcription is a sub-topic in the sixth chapter, of 10 chapters. The students have difficulty in retrieving the facts correctly and in the right order, due to the fact that English is not their mother tongue. Several of the researcher's students had even admitted that they had to learn in Malay, and then translate the facts into English.

The use of English as the medium for Teaching and Learning of Science and Mathematics (PPSMI, the Malay acronym) took effect in 2003 in schools and Matriculation colleges. However, in 2012, schools were allowed to use Malay, and many schools preferred to revert back to the use of the national language, Malay. By this means, school students would not have to 'learn in Malay and translate back to English', as done by the students involved in this study.

Research has shown that primary school students who are first taught Science in the native language can achieve greater general knowledge of the subject (Science), if they are first taught the subject in the mother tongue (Engle, 1975). This shows the advantage of teaching Primary Science in the mother tongue (Malay, in Malaysia). Other studies that showed parallel results on the advantage of the mother tongue in education of children were documented by Cummins (1979); Butler and Marsh (1986); while Yuen and Siu (2014) showed although students became more proficient in English (the second language), that was used as a medium for instruction of content subjects like Science, their performance in the content subjects suffered.

However, for 18 year old matriculation or pre-university students, PPSMI is currently still in effect. (The researcher was given this information at a meeting on 26-28 February 2014, organized by the Matriculation Division of the Education Ministry, for all the Heads of PPSMI in their respective colleges.) The purpose of this project is to enable these students to remember the facts of the Transcription correctly and in the right order.

Although the studies reviewed, in the next section, show that mnemonics are very significant in improving the remembering of facts and improving test scores, not much research has been carried out and documented by Malaysian researchers in this area. The researcher carried out one study on the effectiveness of musical mnemonics to facilitate students' learning of the Krebs Cycle of Respiration (Yeoh, 2012), and went on to investigate students' remembering the Calvin Cycle of Photosynthesis (Yeoh, 2013a), Glycolysis (Yeoh, 2013b) and the Electron Transport Chain of Respiration (Yeoh, 2013c). The purpose of this project is to enable Matriculation students to recall the facts of Transcription correctly and in the right order.

Literature Review

Brief Review on Learning

This section discusses studies on learning. There are three core concepts within Bandura's Social Learning Theory (1977). The first concept is that people learn by observation or modelling. The second concept is internal personal mental states are important to learning; this

personal satisfaction or a sense of accomplishment influences learning and behaviour. It is not just the external environment that plays a role in learning. The emphasis on internal mental states relates Bandura's theory to cognitive theories. Bandura's third concept is that learning does not necessarily produce a permanent change in behaviour.

Bandura (1977) stated that human behaviour is mainly learned through observational learning (or modelling). By observing parents and teachers, children get an idea of how new behaviours are performed. This coded information serves as a guide for subsequent action. In this research, the teacher was the live model, showing the behaviours of how the musical mnemonics are used to draw the Transcription process. She was also the verbal instructional model, giving descriptions and explanations.

The researcher realizes that intrinsic mental states of the students are important for learning to occur, as stated in Bandura's (1977) second concept. Students need to actively assimilate the information in the mnemonics. Active learning is taking place when constructivism links are forged between new and existing knowledge by the student. Since the constructivism links are stronger if they involve recent, vivid, engrossing, multisensory experience (Petty, 2009), the researcher encourages her students to use all learning sensory organs; eyes and ears.

Brief Review on Mnemonics

Mnemonics may be defined as devices that enable students to remember information more easily and effectively. Mnemonics perform this function by connecting the new, unfamiliar information that must be learned and remembered with information that is already known by the learner, with the use of visual and auditory cues (Mastropieri, Sweda, & Scruggs, 2000). Mnemonic strategies, such as acrostics and acronyms, have facilitated individuals to recall information by making new information more familiar, meaningful and more concrete (Bakken & Simpson, 2011). These devices are effective and are used by students to recall information on various subjects. Young adult learners have used mnemonics to improve their vocabulary knowledge (Bakken & Simpson, 2011).

Shmidman and Ehri (2010) found that mnemonics facilitated the learning of foreign alphabets among English-speaking preschoolers (N = 36, 2 years). They suggested that mnemonics were effective to reduce confusion, accelerate learning besides enhancing long-term retention (Shmidman & Ehri, 2010). Mnemonic devices accelerated the rate of acquisition of new knowledge in Elementary Accounting and helped to enhance formal reasoning (Laing, 2010). Laing added that mnemonic devices such as acronyms and acrostics, narratives and rhymes help to make abstract concepts more meaningful. An acronym that students learn to recall the colours of the rainbow is ROY G BIV. This helps them to remember the order of the colours correctly as Red, Orange, Yellow, Green, Blue, Indigo and Violet (Bakken & Simpson, 2011). The author also used this same acronym mnemonics while teaching the spectrum of visible light in the topic on Photosynthesis.

Letter-phonetic mnemonic devices (acronyms and acrostics) have also been used to facilitate recall in basic knowledge acquisition in nursing education (Onur, Ali, Yunus, & Musa, 2013). This study investigated the effect of the letter/phonetic method on nurses' attainment of basic knowledge of the healthcare system, and nurses' recall of this basic knowledge (N=76). In that study, the experimental group (n=39) that was taught using these mnemonic devices. Both the experimental (n=39) and the control groups (n=37) were tested on healthcare system, health teams and the role of nurses. They were given the same test after the study; this was the Attainment test. Using a t-test, the researchers showed that there was a significant difference between the experimental and control groups, ($t = 9.35, p = 0.0005$), in favour of the experimental group that employed letter-phonetic mnemonics (Onur et al., 2013). Three weeks after instruction, the participants were tested again; and the attainment test was

given as a Retention test (Onur et al., 2013). Using a t-test, the researchers showed that there was a significant difference again between the experimental and control groups, in favour of the experimental group that employed letter-phonetic mnemonics ($t = 12.73$, $p = 0.0005$).

Acronym mnemonics had also been used by Schumacher (2005) in nursing practice. Before hanging or pushing medication, nurses, pharmacists, physicians, other healthcare providers, (and even the patients themselves) should ask: Do your CATS PRRR?; where the acronym (CATS PRRR) represents Compatibilities, Allergies, Tubing, Site, Pump, Right Rate, Release, and Return and Reassess. This mnemonic device is to assist nurses to remember the many facets of safe techniques for intra venous medication preparation, administration, and use of the various intra venous pumps. Again it is stressed that the common feature of the mnemonics used by Biology students, medical students and nurses is that they are devices for recall and not for comprehension. Mnemonics do not replace regular lectures and tutorial classes that place importance on student learning and understanding and constructivism, but mnemonics are helpful to facilitate recall for Biology students, medical students and nursing students (Cirigliano, 2013; Onur et al., 2013; Yeoh, 2012, 2013a, 2013b, 2013c).

An acrostic is a form of writing in which the first letter or syllable spells out a word or a message. An acrostic was used by the researcher for students to remember the sequence of organic compounds of the Krebs cycle (Yeoh, 2012). The sentence was: 'Citrus, Isobel, Ketty, sing sulk fume (on) male oxen.' Using this sentence, students can easily remember the sequence from Citrate, Isocitrate, Ketoglutarate, Succinyl CoA, Succinate, Fumarate and Malate. Students can also remember easily the number of Carbon atoms in each of these compounds, because this is provided by the number of letters in the names (Citrus, Isobel, Ketty, sing sulk fume (on) male oxen). By this they remember that Isocitrate has 6 Carbon atoms in its molecule, and Ketoglutarate has 5 Carbon atoms in its molecule. This also reminded the students that a decarboxylation reaction has occurred, that needs a Decarboxylase enzyme. Similarly, from Ketoglutarate to Succinyl CoA, another decarboxylation reaction has taken place, that needs another Decarboxylase. This clue is provided by putting a 5 letter word 'Ketty' for Ketoglutarate, and a 4 letter word 'Sing' for Succinyl CoA. 'Sulk' is another 4 letter word used for succinate. 'Fume' sounds like fumarate, another 4-Carbon compound; and 'male' sounds like malate, also a 4-Carbon compound (Yeoh, 2012).

The sentence: 'Citrus, Isobel, Ketty, sing sulk fume (on) male oxen' was set to the tune of 'Old MacDonald had a farm' that most students are already familiar with, making it a musical mnemonic as well (Yeoh, 2012). The use of musical mnemonics by the researcher to teach Biology is parallel to the study reviewed concerning the use of musical mnemonics as a powerful learning tool in medicine and health science (Cirigliano, 2013). Biology is a basic science for Medical Studies, that comprises Anatomy, Biochemistry pathways, Surgery, Pharmacology, Clinical procedure, Diagnostics, Medication and Treatment. As such, Medicine is a field notorious for 'brutal tests' in memorization (Cirigliano, 2013). Hence, Medicine has a history of mnemonics composed by students and instructors. Medical students needed the memory aids, and many mnemonics, including musical mnemonics have been on online databases such as <http://www.medicalmnemonics.com>. Anatomy mnemonics and Pharmacology mnemonics are available at www.doctorshangout.com. (The webpages were assessed on 8 March 2014.)

Since song has been a form of communication that is present in every culture, and has from ancient times been the medium to pass down significant stories from one generation to the next (Dunlap & Lowenthal, 2010), it is useful to employ musical mnemonics as a learning tool. In this study, song that has the ability to engage students' attention and to enhance their memory is used as a learning tool for Biology, just as it was used for the study of health science (Cirigliano, 2013). Cirigliano (2013) stated that instructors or teachers played a major role in using musical mnemonics from a survey of ten music mnemonics on YouTube. He suggested

that more robust research like meta-analysis could confirm the value of mnemonics in the learning of health science and medicine.

Research on persons with multiple sclerosis has also shown that musical mnemonics facilitated superior learning and memory retention. These patients were able to recall and sing back the words. Thaut, Peterson, and McIntosh (2005) suggested that musical learning accesses compensatory pathways for memory functions; and that music learning confers a neuro-physiological advantage through the stronger synchronization of neuron assemblies underlying verbal learning and memory. The authors concluded that melodic-rhythmic templates within the music may drive internal rhythm formation in recurrent cortical networks involved in learning and memory (Thaut, Peterson, & McIntosh, 2005).

Simmons-Stern, Budson, and Ally (2010) reported that music mnemonics enhanced attention and improved memory recall in patients of Alzheimer Disease (AD). Music processing is generally not affected by the neuron degeneration of AD patients; and so these patients showed better recognition accuracy for the lyrics of unfamiliar children's songs that were sung, as compared to spoken lyrics. The authors proposed that the brain areas serving music processing are spared by AD, allowing a more holistic encoding that facilitated recognition and recall, and that music increases arousal of AD patients producing improved attention and better memory potential (Simmons-Stern, Budson, & Ally, 2010; Yeoh 2013c).

A study was carried out to investigate the effectiveness of musical mnemonics to facilitate the learning of Matriculation Biology and students' retrieval of facts of the Krebs cycle of respiration (Yeoh, 2012). On this occasion, the researcher used a pre-test post-test procedure. A pre-test was administered. Then, the researcher proceeded to teach them the two songs and showed them on the Interactive Electronic Equipment (IEE) scanner how to employ the songs as an aid to recall the facts and processes of the Krebs cycle. After that, a post-test was carried out. The data collected at this meeting was analyzed using the paired sample t-test.

The researcher obtained evidence that musical mnemonics did help Biology students improve their scores. The pre-test mean score for the sample of 145 students was 4.12 (SD = 4.75) of a total of 20. The mean score at the post-test increased to 13.81 (SD = 3.16). Paired samples t-test used in that research showed a significant improvement in post-test scores, $t(144) = 23.45$, $p = .0005$. She had concluded that musical mnemonics was effective in helping students remember the Krebs cycle and had implied that the teaching of Biology in English is facilitated when teachers are innovative (Yeoh, 2012). The studies reviewed have shown that musical mnemonics had facilitated memory recall of normal respondents as well as of respondents who were physically impaired. However, the design of this present study is improved by including a control group. Besides that a non-parametric statistical test was used, that did not assume that the data fits a normal distribution.

It is necessary to emphasise the limitations of mnemonic strategies. Mnemonics are useful only for recall, and they are not comprehension strategies (Bakken & Simpson, 2011); mnemonics only facilitate the recall of new knowledge. The students involved in this study have been given a lecture on Transcription, and they have also had practice in answering structured and essay questions. They admitted they had understood the process, but they just could not remember. With the musical mnemonics that they were taught for Transcription, the students admitted that they enjoyed the learning. This shows that the song that has engaged them has enhanced their recall potential, and is an effective learning tool in this academic setting (Cirigliano, 2013; Yeoh, 2012, 2013a, 2013b, 2013c). Furthermore, research in neuroscience has shown that musical training positively affects brain development; and benefits of training in music last through adulthood. It has been observed that learning to play a musical instrument positively influences IQ and academic performance (Miendlarzewska & Trost, 2014). This suggests that musical mnemonics are valuable for memory recall of complex biological processes (Yeoh, 2012, 2013a, 2013b, 2013c).

Brief Review on the Transcription Process

Transcription bears the meaning of ‘copying’ because the information in the template strand of DNA is copied as RNA. All the three main types of RNA [namely messenger RNA (mRNA); ribosomal RNA (rRNA); and transfer RNA (tRNA)] are transcribed from DNA. Messenger RNA carries the genetic information as codons that will later be translated into a polypeptide or protein. The enzyme that catalyzes the synthesis of mRNA is RNA Polymerase II. This synthesis is carried out in a 5’ to 3’ direction, always adding nucleotides to the 3’ end. Briefly, three processes are involved: Initiation, Elongation and Termination; and then the pre-mRNA must be spliced to become a mature mRNA that moves out of the nucleus, for the next step of Protein Synthesis (Solomon, Berg, & Martin, 2011).

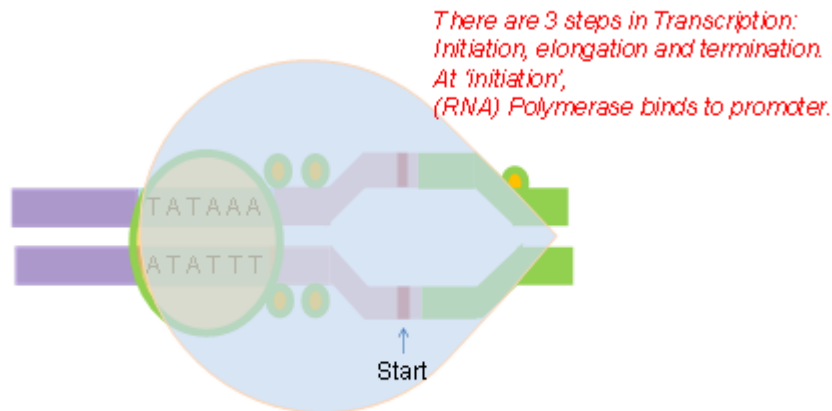
Methodology

Details of Innovation

To enable students remember the Transcription process, the researcher used the simple tune below. It is a variation of ‘Malaysia Berjaya’ a popular patriotic Malaysian song. The song is as below. Since the constructivism links are strengthened when they are used repeatedly by the learner to describe and explain (Petty, 2009), and in order that the new learning becomes more familiar and concrete (Bakken & Simpson, 2011), the researcher encouraged her students to sing the mnemonics and teach them to their friends. After all, learning is essentially a social activity and we learn by observing teachers and peers (Bandura, 1977; Yeoh, 2013c).

‘Transcription is an important process,
It takes place in the nucleus,
The template strand of DNA,
Is transcribed as mRNA.

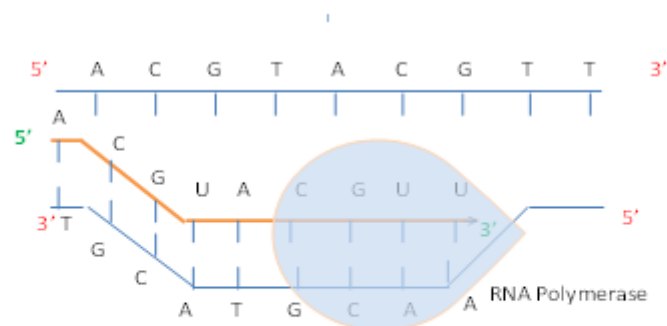
There are three steps in Transcription:
Initiation, elongation and termination.
At ‘initiation’,
RNA polymerase binds to promoter



Polymerase and then other transcription factors form the initiation complex.
DNA unwinds, RNA begins to be synthesized at 'Start'.

Figure 1. Initiation of transcription process.

This enzyme unwinds the DNA,
It then adds nucleotides
to 3' end, so that mRNA
Elongates 5' to 3'.



... ..Elongates 5' to 3'.

Figure 2. Elongation during transcription.

Finally RNA polymerase reaches terminator or 'stop',
RNA polymerase and pre-mRNA
Are released from DNA.'

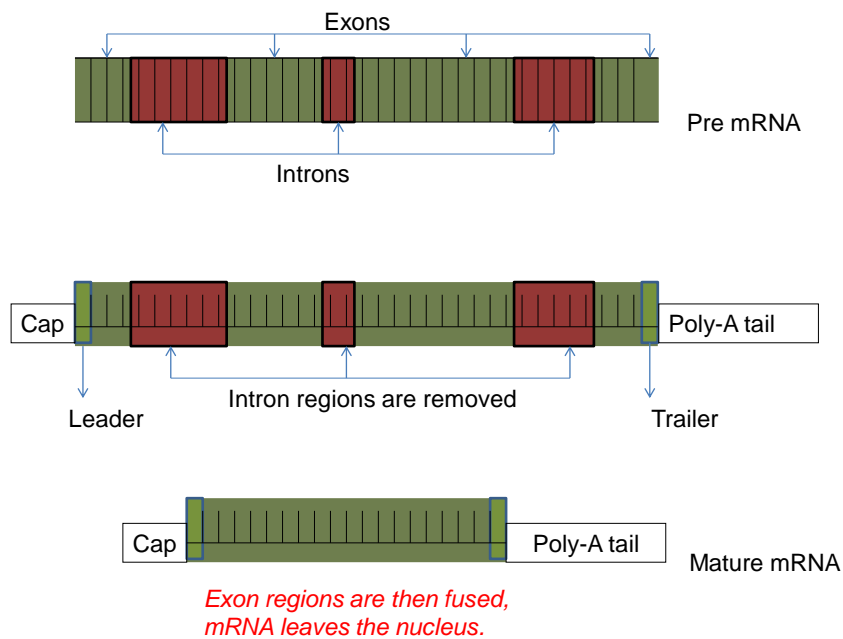


Figure 3. Termination of transcription process.

Introns are removed, and ends of exons
Are brought together and joined,
Exon regions are then fused,
mRNA leaves the nucleus.'

Respondents

The researcher met her target group of 78 students at a late evening class on Monday 2 September 2013 (week 12 of semester). All the students had had lessons on Expression of Biological Information in week 10, and had done tutorial exercises during week 11.

Procedures

Briefly, the researcher explained to them what would be done. They would be randomly assigned to control and experimental groups. The control group would go to the next room and study the process of Transcription, in a conventional manner from their books and notes for 30 minutes. At the same time, the researcher would teach the experimental group the mnemonics and show them how to draw and label a diagram from the information in the mnemonics. Then, they will all take a short test. When it was finished, the researcher would do the same for the control group. The researcher could see from their facial expression, that most students would prefer to be in the experimental group, but they accepted the procedure that she had outlined.

The students were randomly assigned to the two groups so that the control group and the experimental group had equal number of students, 39 each. Each student picked up a folded piece of paper. A 'C' would assign him/her to the control group, while an 'E' would put him/her into the experimental group. The control group went to the next empty room and learned the process of Transcription in a conventional manner. At the same time, the researcher taught the experimental group the musical mnemonics (or 'bio-song'); and showed them on the interactive electronic equipment (IEE) scanner how to employ the tune to draw and label the diagrams. The group had opportunity to observe how the researcher was able to draw diagrams (Figures 1, 2 and 3) using information in the mnemonics (Bandura, 1977). This teaching activity took 30 minutes.

After that, both groups took part in a short test (see Evaluation). The test took 20 minutes. For this test, students were required to answer ten short questions on Transcription. This would show whether they could recall the facts of Transcription.

After all the test papers were collected, the researcher taught the control group the musical mnemonics and showed them how to use it to draw and label the diagrams on Translation. The researcher kept her word; it was the right way to make up for their being in the control group. The experimental group sat quietly and listened attentively. Then, all the students sang happily. The data was analyzed for both groups. All statistical analyses were carried out using SPSS. Finally, to facilitate further research, a video CD of the mnemonics was created using Windows Movie Maker.

Evaluation

1. What is the template for transcription?
2. What are the steps in Transcription?
3. What happens at initiation?
4. What enzyme adds nucleotides?
5. At which end is the nucleotide added?
6. What is the direction for the elongation of RNA?
7. What happens when the enzyme reaches the terminator sequence?
8. What are removed during splicing?
9. What happens to the exons?
10. What happens to the mature RNA?

Results and Discussions

The results showed that the minimum score for the control group was 0, and the maximum was 8 of 10 (total score). As for the experimental group, the minimum score was 9 and the maximum was 10. The means (SD) of the control and experimental groups were 3.92 (1.738) and 9.95 (.223) respectively. The scores of the control group were normally distributed (Shapiro-Wilk statistic = .951, $p = .087 > .05$) but the scores of experimental group were no longer normally distributed (Shapiro-Wilk statistic = .233, $p = .0005$). The experimental group scores were negatively skewed (skewness = -4.233, kurtosis = 16.779). The medians of the experimental group and the control group were 10.0 and 4.0 respectively. The mean ranks were 59.00 for the experimental and 20.00 for the control groups; and the sum of ranks were 2301 and 780 for the experimental and control respectively. A Mann-Whitney test was carried out to evaluate the scores of the two groups. A significant effect was found: $W(76) = 780$, $Z = -8.066$, $p = .0005$.

The effect size was calculated with the use of the formula ($r = z/\text{square root of } N$), and it was found to be 0.9133 which was quite a large effect, when compared to the effects of other mnemonics that produced a moderate effect size (Yeoh, 2013c). The results showed that musical mnemonics were effective to enable students to remember Transcription; by consolidating their memory processes. The results were in line with previous studies employing mnemonics to facilitate memory consolidation (Bakken & Simpson, 2011; Cirigliano, 2013; Onur et al., 2013; Simmons-Stern et al., 2010; Thaut et al., 2005; Yeoh 2012, 2013a, 2013b, 2103c).

Even though the respondents in this study were physically normal (Bakken & Simpson, 2011; Cirigliano, 2013; Onur et al., 2013), not impaired by AD as in Simmons-Stern et al. (2010) nor impaired due to multiple sclerosis (Thaut et al., 2005), they had a handicap, in that English is not their mother tongue. However, mnemonics had facilitated their recall of the

Transcription process. The results of this study are parallel with previous research, including one carried out by the same researcher a year ago on the effectiveness of mnemonics in teaching the Krebs cycle (Yeoh, 2012). The results are also in line with the studies concerning students' ability to remember other biological pathways, namely the Calvin Cycle (Yeoh, 2013a), Glycolysis (Yeoh, 2013b) and Electron Transport Chain (Yeoh, 2013c).

Conclusions and Recommendations

The findings are in line with previous studies that have been reviewed, that employed mnemonics to facilitate memory recall. Based on the findings, the researcher suggests that musical mnemonics should be used to facilitate memorization of other biological processes including DNA Replication and the *lac* operon. This will help reduce the study stress and mental exhaustion that many students face. When the stress is tolerable, they enjoy Biology lessons even more.

The researcher also proposes that students be encouraged to write their own mnemonics. By so doing, we will encourage our students to be independent, creative and innovative! These qualities are necessary for our students to compete in this global era. With the use of the video CD on Transcription, it means that the researcher does not have to sing the mnemonics several times, in order to teach the students.

The research has also benefited the researcher. Previously, she had used a paired samples t-test that lacked a control (Yeoh, 2012). Then, she used independent samples t-test in the research on the Calvin cycle (Yeoh, 2013a), Glycolysis (Yeoh, 2013b) and Electron Transport Chain (Yeoh, 2013c), where equality of variances could be assumed. In this study, she used non-parametric statistics because while the scores of the control group were normally distributed; the scores of the experimental group had become negatively skewed, with many students obtaining the maximum score of ten marks.

The results of this study imply that even Biology, a subject that requires procedural knowledge, can be successfully taught in English. It can be learned in an environment where the mother tongue is the Malay language and not English. This implies that musical mnemonics are a useful tool to facilitate memory consolidation for students, in an environment where Biology is taught and tested in English, to prepare students for university education where the lingua franca is English.

References

- Bakken, J. P., & Simpson, C. G. (2011). Mnemonic strategies: Success for the young adult learner. *The Journal of Human Resource and Adult Learning*, 7(2), 79-85.
- Bandura, A. (1977). *Social learning theory*. New York: General Learning Press.
- Cirigliano, M. (2013). Musical mnemonics in health science: A first look. *Medical Teacher*, 35(3), e1020 - e1026. doi:10.3109/0142159X.2012.733042
- Butler, S., & Marsh, H. (1986). Reading and arithmetic achievement in primary years for students from non-English-speaking families: A seven-year longitudinal comparison. *Australian Journal of Education*, 30, 23-44. doi: 10.1177/000494418603000102
- Dunlap, J. C., & Lowenthal, P. R. (2010). Hot for teacher: Using digital music to enhance student's experience in online courses. *Tech Trends*, 54(4), 58-73. doi: 10.1007/s11528-010-0421-4

- Cummins, J. (1979). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research*, 49, 222-251. doi: 10.3102/00346543049002222
- Engle, P. (1975). Language medium in early school years for minority language groups. *Review of Educational Research*, 45(2), 283-325. doi: 10.3102/00346543045002283
- Laing, G. (2010). An empirical test of mnemonic devices to improve learning in elementary accounting. *Journal of Education for Business*, 85(6), 349-358.
- Mastropieri, M. A., Sweda, J., & Scruggs, T. E. (2000). Putting mnemonic strategies to work in an inclusive classroom. *Learning Disabilities Research and Practice*, 15(2), 69-74. doi: 10.1207/SLDRP1502_2
- Michael, J. (2006). Where's the evidence that active learning works? *Advances in Physiology Education*, 30, 159-167. doi:10.1152/advan.00053.2006
- Miendlarzewska, E., & Trost, W. (2014). How musical training affects cognitive development: rhythm, reward and other modulating variables. *Frontiers in Neuroscience*, 7, 1-18.
- Onur, K, Ali, M. S., Yunus, E. O., & Musa, O. (2013). The impact of mnemonic devices on attainment and recall in basic knowledge acquisition in nursing education. *Mevlana International Journal of Education*, 3(4), 265-278.
- Petty, G. (2009). *Evidence Based Teaching* (2nd ed.). Nelson Thornes: Cheltenham.
- Schumacher, D. L. (2005). Teaching tips: do your CATS PRrr?: A mnemonic device to teach safety checks for administering intravenous medications. *Journal of Continuing Education in Nursing*, 36(3), 104-106.
- Shmidman, A., & Ehri, L. (2010). Embedded picture mnemonics to learn letters. *Scientific studies of reading*, 14(2), 159-182.
- Simmons-Stern, N. R., Budson, A. E., & Ally, B. A. (2010). *Music as a memory enhancer in patients with Alzheimer's disease*. Retrieved 1/5/2013, from <http://www.ncbi.nlm.nih.gov/pubmed/>
- Solomon, E. P., Berg, L. R., & Martin, D. W. (2011). *Biology* (9th ed.). Canada: Brooks/ Cole, Cengage Learning.
- Thaut, M. H., Peterson, D. A., & McIntosh, G. C. (2005). *Temporal entrainment of cognitive functions: Musical mnemonics induce brain plasticity and oscillatory synchrony in neural networks underlying memory*. Retrieved 1/5/2013, from <http://www.ncbi.nlm.nih.gov/pubmed/>
- Yeoh, M. P. (2012). *The effectiveness of musical mnemonics in teaching biology: Krebs' Cycle*. Paper presented at IPGM International Convention for Teacher Learning and Development, 19-21 Nov 2012; Pearl International Hotel, Kuala Lumpur.
- Yeoh, M. P. (2013a). *Musical mnemonics to facilitate the learning of matriculation biology: The Calvin Cycle*. Paper presented at National Convention of the Teacher Division, Ministry of Education, Malaysia, 22-24 October 2013; Le Grandeur Hotel, Senai, Johore Baru, Malaysia.
- Yeoh, M. P. (2013b). *Musical mnemonics to facilitate the learning of matriculation biology: Glycolysis*. Paper presented at 5th CoSMed International Convention, 11-14 Nov 2013; SEAMEO RECSAM, Penang, Malaysia.
- Yeoh, M. P. (2013c). *Musical mnemonics to facilitate the learning of matriculation biology: Electron Transport Chain*. Paper presented at 5th CoSMed International Convention, 11-14 Nov 2013; SEAMEO RECSAM, Penang, Malaysia.
- Yuen, Y. L., & Siu, E. (2014). A meta-analysis of the effectiveness of English-medium education in Hong Kong. *Review of Educational Research*, 84, 47-73. doi:10.3102/0034654313499615