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Increasing Attention and Working Memory in Elementary Students Using Mindfulness Training Programs

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Short attention or attention deficit among children is now a problem for students. It affects many aspects of daily life, such as restlessness or lack of concentration, which affects the learning effectiveness in their studies. Mindfulness training, systematic training of the mind with a focus on attention and self-regulation, helps improve attention and has a negative relationship with stress. This research was to investigate the effects of mindfulness training in elementary students by comparing the mean scores of response accuracy and reaction time. The sample consisted of 60 elementary students, randomly assigned into groups, the first group being those trained with the audiovisual mindfulness program, and the second being the control group. The training program took place over four weeks, three days per week, and 30 minutes per day. The main finding of this research was that the mean response accuracy scores for attention and working memory after audiovisual mindfulness training, and without training revealed that scores of attention and working memory of the experimental group was higher than those of the control group. However, the response time for attention and working memory of the groups were not different.

***Keywords*:** attention, elementary students, mindfulness training programs, pretest and posttest control group design, working memory

Mindfulness training refers to a systematic training of the mind with the focus on attention and self-regulation (Tang et al., 2013). The purpose of mindfulness training is to train for self-awareness all the time while one is engaged in bodily activities as well as the awareness of one's thought. Mindfulness training can be classified into various patterns which differ in the way to control the mind or the posture taken during the training, mostly taking the form of training by repetitive action. Mindfulness training requires a target selection and attention to the target and the change of the target.

The selected target can be anything, for example, feeling of the physical body such as itchiness or pain, noise of the physical body or the environment, and things such as picture and flame. Mindfulness training yields better results when the training is serious, and continual for a long period of time (Siegel et al., 2009).

Neuroscience research on the benefits of mindfulness training revealed that mindfulness training was positively related to the activities of the left brain which controls the emotion (Davidson et al., 2003) and that it positively influenced adjustment to negative incidents and stresses (Aftanas & Golocheikine, 2002). In addition, mindfulness training helped develop

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working memory efficiently (Bachmann et al., 2018) and helped improve attention (Black & Fernando, 2014).

Attention refers to the process which helps one choose and focus on the feeding of data especially for further processing while keeping out irrelevant data which could disrupt the mindfulness (Stevens & Bavelier, 2012); hence it helps the mind perceive only necessary data among a large pool of data. Without control of attention, the data may flow to unawareness. Hence, attention covers both awareness and unawareness (Rojanakosol, 2009). Attention is a complex structure which is related with the activities of working memory and high-level control to separate important items from a large quantity of sensory data (Luck & Gold, 2008). It has an important role of modulation of encoding to increase the efficiency of memory recovery (Chun & Turk-Browne, 2007), and attention and short-term memory closely react in modulation of coding (Fougnie, 2008) which influences the capacity of memory while working (Unsworth et al., 2014).

Working memory is essential to many complex cognitions such as problem solving, reading comprehension, attention control, and fluid intelligence (Sut et al., 2002). Working memory has many functions including temporary storage, processing of information and manipulation of information in activities of everyday life and continuously deals with information while the brain is working (Bayliss et al., 2005).

A study to increase attention by Integrative Body-Mind Training (IBMT) and music auditory was conducted and it was found that the experimental population could respond to questions more quickly and more correctly with less anxiety, depression and anger (Tang et al., 2007). Mindfulness practice of three hours per day over a period of 10 days among a group of people with the age ranging from 18-30 years old was studied. After the mindfulness practice, the group was given an attention network test on computers which revealed that the group with the practice performed better in accuracy and response time than the control group. This indicated that mindfulness practice increased attention (McLaren et al., 2010).

For the purpose of enhancing attention and working memory, a study of mindfulness training by visualization and auditory was conducted using a sample group of 50 people divided into two groups: 1) mindfulness training by observing different pictures including colorful pictures, mandala pictures and scenic pictures, and 2) mindfulness training by listening to auditory including the auditory of music, mandala, mantra, and the auditory of scenic nature. Results of the study revealed that mindfulness training by visualization or auditory helped increase the score from the measurement of attention and working memory (Campillo et al., 2018). In addition, Beattie et al., (2018) studied mindfulness practice to enhance the potential of working memory unit in children. Brain function in managing the work of the memory unit is very important for success in education, social relationship and attention.

From the systematic review of documents and researches, one can see that mindfulness practice gives positive influences on the development of attention, working memory, concentration practice and emotion control, all of which are useful for learning and everyday life living of teenagers. It is therefore considered important to study mindfulness practice for enhancing attention and working memory by using the methods of Campillo et al., (2018); Wannapoklang et al. (2019) which use audiovisual mindfulness program to enhance attention and working memory of elementary students.

Research objectives

1. To compare attention in elementary students before and after the mindfulness training program.
2. To compare working memory in elementary students before and after the mindfulness training program.
3. To compare attention and working memory in the students of the experimental group with mindfulness training and the control group.

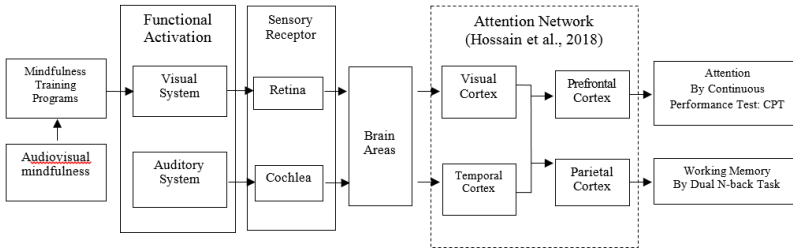
Conceptual Framework

A mindfulness training program is the training program with the objective of enhancing attention and working memory of the trainees. The training program may employ different techniques to help achieve its objective. For the audiovisual mindfulness training program adopted in this study, functional activation is by the visual system with the sensory receptor being the retina, and by the auditory system with the sensory receptor being the cochlea. These systems send out neural signals to different areas of the brain. Hossain et al., (2018) discussed the function of the brain in relation to mindfulness training. It was discovered that mindfulness training in the form of repeated practice was related to the attention network. As the retina and the cochlea are stimulated by the image and sound signals, the signals will be sent to the visual cortex and the temporal cortex of the brain which will translate the stimulus signals to the prefrontal cortex and the parietal cortex.

The brain system of the attention network including the visual cortex, the temporal cortex, the prefrontal cortex, and the parietal cortex influences the cognitive processes such as attention and working memory. Attention can be measured by the Continuous Performance Test (CPT) in Psychology Experiment Building Language (PEBL) program (Mueller & Piper, 2014) via the computer screen. Attention test results include correct trials with the unit in points, and reaction time (RT) in milliseconds (ms) whereas the working memory is measured by the test called Dual N-back Task in PEBL program (Mueller & Piper, 2014) as well. Working memory test results are given as correct trials and reaction time as in the case of attention.

The author envisions the advantage of using the mindfulness training program in enhancing attention and working memory and is interested in conducting research to determine the effectiveness of the program with the conceptual framework as illustrated in Figure 1.

Figure 1
Conceptual framework



Method

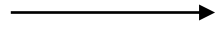
Research Design

This research was a pretest and posttest control group design (Edmonds & Kennedy, 2017) with the experimental scheme as shown in Figure 2. Based on the study of Au et al., (2020), who examined meta-analytical techniques comparing the two control groups and discovered no appreciable performance difference between passive and active controls, this study used a passive control group rather than an active control group.

Figure 2

Pretest and posttest control group design

Group	Pretest	Treatment	Posttest
1	O_1	X_A	O_2
2	O_1	-	O_2



Time

Sample and Data Collection

The population of this research was elementary students in six classes (Grade one - six) of Wonnapasub School in Chonburi, Thailand, in Semester 1 of Academic Year 2021 with the total number of 112 students.

The sample group comprised the students of the population who volunteered to participate in the project. By examining personal data in the questionnaires, all members of the group had the qualifications as specified.

Determination of the sample size was based on the influence of the variables consistent with the population distribution. The computer program, G*power, was used to determine the sample size to be 45 students. In order that greater reliability and accuracy might be obtained, the sample size was chosen to be 30 students in a study group (Mcmillan & Schumacher, 2014). Being consistent with the experimental design, it was found that the sample size consisted of 60 students divided into two groups. The first experimental group consisting of 30 students practiced audiovisual mindfulness training, and the second control group of 30 students without mindfulness training. Simple random sampling was used in dividing the sample size into two groups using the criteria that follow.

Rights Protection of the Research Subjects

The researcher explained the objective, procedure, and method of this research to the participants in the sample groups before asking for their agreement to participate in the research. The participants were also informed that they could withdraw from participating at any stage of the research, and that all the information and data of the participants would be confidential, and only the summary and overall results might be disclosed for academic purpose. This research was conducted in accordance with the ethics of research in humans, and it was approved by the research ethics committee of Burapha University and given the research project code HU033/2564.

Research instruments

The instruments used in this research could be divided into four types including sample screening instrument, experimental instrument and data collection instruments as explained below.

Sample screening instruments

1. A questionnaire for personal information such as gender, health conditions, prevailing illness, normal hearing and normal vision.

2. A hearing test employed the method of finger rubbing one inch away from an ear on both ears. If the finger rubbing sound was heard, the hearing was normal. This research selected only those with good hearing in both ears to participate in the experiment.

3. Evaluation form for near vision using Jaeger Chart

4. Ishihara Color blindness screening form

Experimental instrument

The experimental instrument based on the mindfulness training program of Campillo et al., (2018) was developed for use in this study. The program design followed the principle of Kramer (2012) and Wannapoklang et al., (2019) which passed quality examination and approved by experts. The program which employed audiovisual techniques for mindfulness training took four weeks, three days per week, Monday, Wednesday and Friday, and 30 minutes per day. The mindfulness training group was instructed to focus their attention on specific images and sounds that corresponded to those images, including: 1) color images and sounds; 2) mandala images and mantras sounds; and 3) landscape images and sounds.

Data collection instruments

1 Continuous performance test (CPT) which was employed to measure attention via a computer screen (Mueller & Piper, 2014). Results of the test included correct trials with the unit in points and the reaction time (RT) in milliseconds (ms).

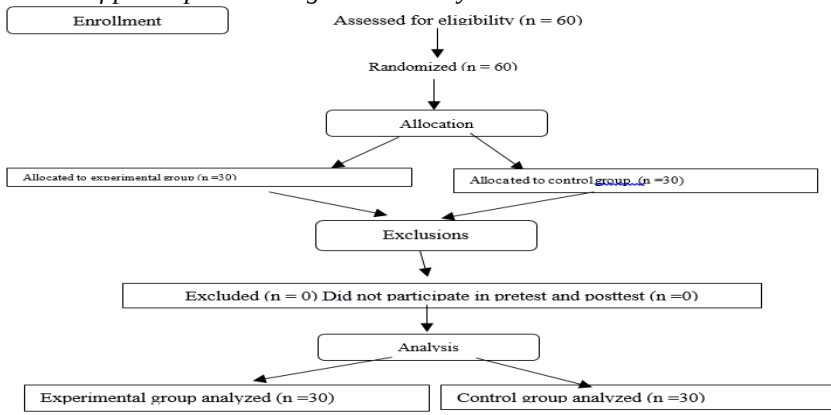
2 Dual N-back Task test on a computer screen, a instrument for measuring working memory developed by PEBL. Test results consisted of correct trials in points and reaction time in milliseconds.

Data Collection

Before the commencement of the experiment, the researcher sent out a letter to the principal of Wonnapasub School in Chonburi, Thailand to seek participation from the students in elementary classes of the school. The objective, procedure, method, and the potential impact of the research were explained to the principal. The students were asked to participate on a voluntary basis, and those who agreed to participate were required to sign consent forms before data collection. During the recruitment, there were 60 students completed the screening process to determine their eligibility for inclusion in the current study. Figure 3 depicts the entire recruitment process as well as the intervention phase. The students were divided into two groups, one was for audiovisual mindfulness training and the other without the training. Both groups were tested for attention by the Continuous Performance Test (CPT) and working memory by the Dual N-back Task Test in the PEBL Test (Mueller & Piper, 2014). After the tests, the data were collected and examined to check validity for further analysis.

Figure 3

Flow chart of participants throughout the study



The experimental group intended for mindfulness training were trained by the audiovisual mindfulness training. The training program was delivered via Zoom.us, web-based software, which enables participants to see and communicate with the teacher and other group members via webcam. Classes were recorded so that individuals who missed a class could view it later. Participants in the program which lasted four weeks were instructed to practice on their own for 30 min three times a week via a secure online web-portal which provided either guided meditation recordings or writing prompts depending on group assignment. The portal recorded the amount of time students spent practicing. The practice frequency and duration were designed to meet requirements for a future workplace implementation of the program.

Before and after the experiment, the experimental group with the training and the control group were tested online for attention by CPT and for working memory by the Dual N-back Task Test. Data were collected and examined for validity for further analysis.

Analysis of Data

1. An analysis of general data by basic statistics in terms of frequency and percentage was made.
2. Comparison of attention and working memory scores of the group with mindfulness training before and after the mindfulness training was carried out by using dependent *t-test*.
3. Comparison of attention and working memory scores after the experimental period of the sample groups with and without mindfulness training was made by one-way ANOVA, in an effort to reduce risk of error during hypothesis testing (Gravetter et al, 2020).

Results

The results of mindfulness training to enhance elementary students' attention and working memory while studying are outlined below.

The elementary students' attention response accuracy of the experimental group after the training was significantly higher than before, but the average of pre-post reaction times was not different as shown in Table 1.

Table 1

Results for comparing students' accuracy scores, and reaction times of attention for elementary students before and after audiovisual mindfulness training

Attention	*n*	*M*	*SD*	*df*	*t*	*p*	Cohen's d
Accuracy score							
Before audiovisual mindfulness	30	320.82	27.72	29	-2.49*	.02	.40
After audiovisual mindfulness	30	331.00	22.14				
Reaction time							
Before audiovisual mindfulness	30	350.27	34.93	29	1.27	.22	.14
After audiovisual mindfulness	30	345.70	29.80				

The elementary students after audiovisual mindfulness training were found to have higher accuracy scores of working memory with the statistical significance level of .01. It was also found that after audiovisual mindfulness training, the response time of working memory was less than before the training with the statistical significance level of .05 as shown in Table 2.

Table 2

Results for comparing students' accuracy scores, and reaction time of working memory of elementary students before and after audiovisual mindfulness training

Working memory	*n*	*M*	*SD*	*df*	*t*	*p*	Cohen's d
Accuracy score							
Before audiovisual mindfulness	30	2185.75	93.48	29	-13.73**	<.01	1.75
After audiovisual mindfulness	30						
Reaction time							
Before audiovisual mindfulness	30	2311.31	245.17	29	2.08*	< .05	.45
After audiovisual mindfulness	30	2223.19	127.14				

The test of variance of attention and working memory between the experimented group and the control group by Levine's Test revealed that the variance of correct scores and the variance of attention response time yielded p > .01 which was statistically insignificant. Therefore, it could be concluded that attention and working memory of the two groups were not different and that the finding was consistent with assumption used in the analysis of variances. The result of ANOVA analysis of attention and working memory response accuracy revealed that scores of attentions and working memory of the groups were significantly different. However, the response time for attention and working memory of the groups was not different as illustrated in Table 3.

Table 3

Comparison of attention and working memory of elementary students after mindfulness training

		SS	*df*	*MS*	*F*	*p*
Attention	Accuracy score					
	Between	5134.31	1	5134.31	7.49*	< .05
	within	39754.86	58	685.43		
	total	44889.17	59			
	Reaction time					
	Between	1290.48	1	1290.48	0.72	.40
	within	103705.60	58	1788.03		
	total	104996.07	59			
Working memory	Accuracy score					
	Between	94571.75	1	94571.75	10.90*	< .05
	within	503385.31	58	8679.06		

total	597957.06	59			
Reaction time					
Between	9450.77	1	9450.77	0.24	.62
within	2244628.04	58	38700.48		
total	2254078.81	59			

Discussion

Comparison of the students' attention before and after audiovisual mindfulness training revealed a higher average score after the training than that before the training with the statistical significance level of .05, but the response time of the attention test before and after the training was not different. The finding is in agreement with the work of Morrison et al. (2014) who studied to reduce distraction among 58 university students. The students were divided into two groups, one with mindfulness training and the control. The experiment lasted seven hours over the period of seven weeks. Results of the experiment revealed that the group with mindfulness training scored better in the attention test than the control group, but the response time was not different. Furthermore, the correctness of the answers and the calculational accuracy of working memory were not different. It can therefore be concluded that mindfulness training enhanced attention.

Furthermore, it is congruent with Hossain et al., (2018), who demonstrate how trained visual and auditory mindfulness practices are related with the attention network. Sensory receptors, such as the retina in the visual system and the sensory receptor Cochlea in the hearing system, send nerve impulses to various brain locations during training. Furthermore, the findings of this study are compatible with those of Wannapoklang (2019), who found that, following mindfulness practice, 5^{th} grade students' score of attention response accuracy increased significantly compared to prior training, but there was no difference in reaction time.

The brain function and well-being of students will be affected by their increased attention. Self-control has been demonstrated to promote school preparedness (Willis & Dinehart, 2014) and to aid in the development of concentration and self-awareness (Weare, 2013) and self-regulation (Khan et al., 2020), which leads to improved academic competence Duncan et al. (2007) discovered a link between self-control and academic achievement, and mindfulness activities were found to increase academic performance (Byrne, Bond, & London, 2013; Prasertcharoensuk et al., 2020; Makmee, 2021).

Comparison of working memory of the students before and after the audiovisual mindfulness training revealed that the average score of working memory was significantly higher than before the training and the average response time of working memory after the training was less than before the training which was in agreement with the theory of learning by multimedia of Mayer (2009) who stated that audiovisual multimedia resulted in more effective learning than a single medium, and enhanced working memory. The finding of our study was also consistent with the work of Mrazek et al., (2013) who studied mindfulness training for enhancing memory and efficiency in intelligence test by reducing inattention in a group of 48 undergraduate students. The results of their study discovered that mindfulness training, on the average, improved test score and accuracy in the intelligence test by 16%, indicating that mindfulness training for two weeks could increase the efficiency of working memory as well as the increase in reading efficiency while doing the intelligence test (GRE). This is in line with Wannapoklang (2019) findings, which showed that, after training, accuracy of working memory was substantially higher than before. However, the response time was the same. It also aligns with the findings of Greenberg et al., (2019), who investigated mindfulness training as a way to prevent

proactive disruptions in thinking memory. When compared to the control group, the mindfulness group had a considerably higher rate of disturbance errors.

Comparison of attention and working memory in the two groups, one with audiovisual mindfulness training, and without training, indicated that the accuracy scores of attention and working memory of the groups were significantly different. This is in agreement with the work of Campillo et al., (2018), who studied audiovisual mindfulness training for mood adjustment and improving attention and working memory. The results of this study revealed enhanced memory and attention after mindfulness training. This finding is in agreement with the work of Quach et al., (2016), who studied the influence of mindfulness training on working memory in teenagers. It was discovered that there was a significant difference of working memory scores before and after training in the group with mindfulness training while there was not a significant difference in the other groups. In the other tests of the study, none of the groups displayed significant difference.

The finding also agrees with the work of Levy et al., (2011), who conducted a preliminary study on the influence of mindfulness training on multitasking capacity as well as relaxation technique for stress and bodily fatigue. The sample groups were the company's employees and the training spanned over a period of eight weeks. The test involved an assignment of a range of tasks for the volunteers to perform before and after the training. The employees with mindfulness training were found to have less stress, improved memory, better attention to the task at hand, and less employment change. This finding is also in agreement with the work of Chambers et al., (2008), who investigated the capacity of intensive mindfulness on understanding and feeling of mentally retarded persons. There were 20 volunteers who received tests before and after the intensive mindfulness training for a period of 10 days. From the continuous evaluation of working memory and attention, it was found that the trainees had improved mindfulness, recovered from depression, had improved efficiency of the working memory unit, and improved attention continuously and significantly. This study indicated the future trend for the explanation of important processes useful for treatment by mindfulness training.

Based on a review of research on the use of mindfulness training and its effects by Jha et al., (2019), mindfulness meditation was proven to have a positive influence on working memory. Due to the memory system used while thinking, it is necessary to pay attention to details in order to properly insert information. It necessitates considerable attention in order to have a solid and accurate encryption of the data (Lewis-Peacock et al., 2018; Shipstead et al., 2016). The effect of strict mindfulness meditation on working memory was investigated by Baranski and Was (2018). Mindfulness training was proven to be ineffective at improving working memory after two weeks of practice. However, if the training is lengthy, it is likely to have an impact on working memory. This could explain why, after four weeks of training, this study found gains in working memory.

The result of this study is also consistent with research by Jha et al., (2017), who studied short-term mindfulness training using the training course called Mindfulness-based Mind Fitness Training (MMFT) with a total duration of 8 weeks. The subjects were divided into 3 groups: two experimental groups, namely M8T group and M8D group, and the control group. They found that mindfulness training prevented deterioration of cognitive memory. The results showed that the mindfulness groups had higher scores on the accuracy of working memory, but the reaction time was not different.

Conclusion

Although this research study showed that mindfulness training might enhance the research participants' attention and working memory, there are still some unanswered questions

regarding how the training actually improved their abilities. The meta-analysis study by Gobet and Sala (2022) discussed the unrealistic optimism of cognitive training and other artifacts that might have an impact on the study's findings, such as sample errors, use of a control group, or other artifacts. To ensure that sampling error was minimized, the sample in this study was split into two groups using a randomization procedure. Additionally, the subjects took a pre-test before training to ensure there were no individual differences. This research found that elementary students with audiovisual mindfulness training performed, in terms of attention and working memory, better than those without the training, with the accuracy scores of attentions and working memory of the groups being statistically significantly different.

The findings of this study are in line with the field of educational research which can be used to promote academic achievement. Students who regularly participate in mindfulness training programs will have greater attention and working memory. This is another option for improving attention and working memory to boost students' focus and effort, while school administrators use it as a guideline for formulating policy. In addition, to improve students' attention and working memory, teachers can blend mindfulness training programs with other subjects or instructional strategies.

Recommendations

Audiovisual mindfulness training enhances attention and working memory of the elementary students participating in the project. Based on the findings of the present study and those in the literature review, recommendations for improving attention and working memory are made as follows: 1) Students who continuously practice mindfulness can improve their attention and working memory. Mindfulness training is therefore an alternative technique for enhancing attention and working memory. 2) Schools can adopt the audiovisual mindfulness training program of this research to enhance attention and working memory of students. The training program can be integrated in various subjects or can be integrated with other teaching techniques to increase teaching and learning efficiency. 3) Administrators of educational institutions at various levels can use the results of this study in the formation of policy to enhance attention and working memory of students. 4) Various government and private agencies responsible for education and social affairs can use mindfulness training to enhance potential of teenagers.

Acknowledgments

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