The Relationship Of Working Memory Capacity And The Ability Of Undergraduate Mathematics Education Students In Working On Integral Problems

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Abstrak

This research aims to determine the relationship between working memory capacity and the ability of Bachelor of Mathematics Education students in working on integral problems. This research is a qualitative descriptive study. This research was conducted on students of the Undergraduate Mathematics Education Study Program at Muhammadiyah University Enrekang (UNIMEN) for the 2023/2024 academic year. The collection techniques used are complex range assignments, written tests and interviews. The written test in this research is in the form of 6 numbers of Integral Material Test (TMI) questions. To measure students' working memory capacity, complex span tasks were used, namely the forward digit span task and the backward digit span task. Interviews in this study were conducted with one student who had a high working memory capacity and one student who had a low working memory capacity. The stages carried out by researchers in conducting this research were data reduction, data presentation and conclusions. The conclusion of this research is that there is a significant relationship between Bachelor of Mathematics Education students who have high working memory capacity and Bachelor of Mathematics Education students who have low working memory capacity in working on mathematics problems, where students who have high working memory capacity are better able to work on problems. integral correctly compared to students who have low working memory capacity.

Keywords: Working memory capacity; student abilities; integral questions

1. Introduction

One of the advantages of humans is the ability to mentally manage information in an active state and availability of access, simultaneously such as planning, reasoning, problem solving, reading, and abstraction. Of course, some people perform these tasks more successfully than others.

Working memory is a metaphor used by cognitive psychologists to describe the ability to manage and process relevant information simultaneously and purposefully. The concept of working memory essentially reflects a form of memory, but it is more than just memory, working memory, to serve complex cognitive processes. Working memory has multi-components, or a collection of inter-related processes, which include several important cognitive functions (Miyake & Syah, 1999).

Working Memory Model

The working memory model assumes a limited capacity system, which retains temporary information and supports human thought processes by providing a meeting point between perception, long-term memory and action (Baddeley, 2000; 2003; Baddelely & Hitch, 1974; Miyake & Shah, 1999). Compared with other models of short-term storage systems (Atkinson & Shiffrin, 1968), Baddeley's working memory model emphasizes a combination of storage, processing and subsystem differences. Although there are various theories of working memory (Miyake & Shah, 1999), most of these theories agree on the need for a limited capacity attentional system, supplemented by a peripherally based storage system (Baddelely, 2003).

The author will explain the multi-component working memory model developed by Baddeley (Baddeley & Hitch, 1974) and the more general Cowan model (Cowan, 1988). Both models assume that working memory has a limited capacity and functions on a number of tasks of a certain time duration. The following is a description of some of the differences between the Baddeley model and the Cowan model. Baddeley Model. Baddeley's model claims that working memory consists of three components: the central executive and two subsystems, the phonological loop and the visuospatial sketchpad (Baddeley & Hitch, 1974). Central executive tasks as memory resources that can be used by any of the sub-systems. The central executive is responsible for how and when both subsystems are used. Then Baddeley's model becomes more detailed, the central executive is described as having three main tasks. The first focuses one's attention on a particular task and prevents distraction from other tasks. Second, control the distribution of attention. The central executive helps a person when working on several tasks at the same time. The third is switching (Baddeley, 2001), namely determining tasks that have high priority and must be focused on at a certain time.

The second component is the phonological loop (Baddeley & Hitch, 1974), responsible for hearing the information being worked on. The phonological loop repeats auditory information so that the information does not fade from working memory before it is finished using it. Repetition in the phonological loop is in the form of repeating information over and over again. Some information is not transferred from working memory to long-term memory. Someone maintains information online so that it can be used, the information must be repeated so that it is not lost. So, the phonological loop functions to store verbal information in working memory.

Conrad and Hull (1964) found that when the words in a list sounded similar, people had difficulty recalling the words accurately in serial order. Baddeley, Thomson, and Buchanan (1975) also found that as word length increased, participants had difficulty recalling the words in a list. The longer a word, the less time it can be repeated. So, less repetitive words are more likely to be forgotten.

The third component is a visuospatial sketchpad (Baddeley & Hitch, 1974). This component functions to maintain visual and spatial information for a limited time. A visuospatial sketchpad allows a person to mentally manipulate the scene setting (Baddeley, 2001). For example, a person works mentally on a subtraction problem that visualizes numbers. If faced with a number lending operation, the person must mentally subtract one of the digits on the left and place one in front of the digit on the right. Theoretically, both manipulations are performed in a visuospatial sketchpad, not only are numbers manipulated but the individual must remember all the manipulations that have been performed throughout the course of the problem to solve the problem accurately.

Baddeley, Grant, Wight, and Thomson (1975) found that following an object visually resulted in decreased performance on other spatial tasks. However, Brooks (1967) found recall of spatial information was more impaired by a visual task than by an auditory task. This study proves the existence of a visual and auditory system in working memory, and when two tasks involve the same subsystem there is a cognitive deficit than if the two tasks are carried out by different subsystems.

There are several questions about working memory that Baddeley's multicomponent model cannot answer (Baddeley & Hitch, 1974). As mentioned previously, there is a limited number of tasks or stimuli that can be held in a person's working memory at any point in time. There are several strategies to increase the retention of the amount of information in working memory at a given point in time. One strategy is chunking. A person can increase the storage of the amount of information in working memory, by combining several individual pieces of information into one, more complex, piece of information. For example, when a person is asked to remember a series of numbers, he or she may try to group single numbers into more complex numbers, such as years (for example, 1, 4, 9, and 2 can be combined to make 1492). While the concept of chunking appears to be very basic (e.g. Miller, 1956), multicomponent models do not explain the chunking process (Baddeley & Hitch, 1974). Chunking turns more complex stimuli into more manageable chunks of information by linking the information to something already stored in long-term memory. The number 1492 above is not a random number, but is stored in long-term memory as the year Columbus sailed from Spain. Therefore, other components of working memory are needed to answer questions about the working memory system that can retrieve information from long-term memory.

An episodic buffer component was added to the multi-component model of working memory later (Baddeley, 2001). Baddeley and Hitch's (1974) model originally assumed that each subsystem had limited storage capacity and that the central executive was in charge of controlling how much attention a task received. However, none of these three components interact with long-term memory. The episodic buffer not only combines information currently in working memory with information in long-term memory, but the episodic buffer also functions as a translator so that information in the two subsystems can be integrated. Thus, the episodic buffer integrates information in the phonological loop and the visuospatial sketchpad.

Cowan Model. Cowan's (2000) working memory model is more general, assuming that working memory does not consist of subcomponents but rather includes a number of processes that can store a limited amount of information that can be accessed for a limited time. Cowan's findings contained more types of information than just visuospatial and auditory. Thus, there are unlimited subsystems, perhaps applicable to working memory, resulting in a general working memory model that is more appropriate than a specific multicomponent model. Cowan's (1988) model emphasizes two main types of information in working memory, namely information that is currently active in working memory and information that is the center of attention. When someone is working on several tasks, there are several pieces of information that are being used in working memory. Even if a person has several pieces of information in working memory at one point in time, only a small portion of that information can be focused on at that one point in time.

There are many pieces of active information in working memory, but only a few pieces of information get a person's attention. The main difference between Cowan's (1988) model and Baddeley's model (Baddeley & Hitch, 1974) is the idea of special functions of certain subcomponents in Baddeley's model but not in Cowan's model. Studies of working memory have shown that verbal stimuli and visual stimuli do not cause much interference with each other because the stimuli come from different domains. This lack of interference is interpreted as the presence of multiple components in working memory. Reisberg, Rappaport, and O'Shaughnessy (1984) conducted a study in which participants used their fingers to store information in working memory, showing people can use their fingers to work on working memory information without disturbing the information that would otherwise be retained by the loop. phonology or visuospatial sketchpad. Reisberg, et al. (1984) found evidence that there is no limit to the number of subsystems in working memory. While there is some doubt about the subsystems in Baddeley's model, Cowan's model is very general and not particularly tendentious. This paper draws on the idea that limited resources are an important characteristic of working memory. Therefore, rather than just looking at the more general construct of working memory, it is necessary to pay attention to individual differences in working memory capacity as well.

Working Memory Capacity

Barrett, Tugade, and Engle (2004) showed that the construct of working memory capacity is similar to the function of the central executive component in Baddeley's working memory model (Baddeley & Hitch, 1974). Working memory capacity was measured with multiple span tasks. The span tasks discussed below test people's ability to focus on two tasks at the same time. The most important aspect of span tasks is that the processing components of each task must interact with the rehearsal components of the exercise (Conway, et al., 2005). As tasks compete for working memory resources, people with smaller working memory capacities will show deficits in performance on one task, if not both tasks at the same time, while people with larger working memory capacities will show fewer deficits in performance.

The operating span task (O-SPAN, Turner & Engle, 1989) is one version of the task measuring working memory capacity span. Participants are shown math problems and answers; the participant's task is to determine whether the answer is correct for the math problem. After responding to a math problem, participants were shown a word at the end of the math problem and a series of paired words, participants were asked to recall each word. The number of math problems and word pairs in a set varied between two and six pairs per set. Unsworth, Heitz, Schrock, and Engle (2005) chose to use sets of math problems and word pairs that varied from set to set, while other researchers chose to use increasing set sizes, increasing until the task ended. The benefits of the format used by Unsworth, et al. (2005) is that participants cannot predict the size of the next set. However, the O-SPAN task is difficult and is built on the idea that people focus attention on two separate tasks, if the person predicts how many pairs will be in the next set then there may be a third task for the person to work on. Thus, it makes more sense to stick with the format of sets presented in increasing increments so that only two tasks compete for working memory resources.

The reading span task (R-SPAN, Daneman & Carpenter, 1980) was one of the first working memory span tasks. R-SPAN participants were asked to read the sentences aloud and told that they were expected to recall the last word of each sentence. At the conclusion of the set, participants recalled the last word of each sentence. The number of sentences increases from set to set. Span tasks are built on the assumption that one task involves processing information and the other task retains information. In this R-SPAN task, it is difficult to know whether the participant is actually processing the sentence or just reading the sentence aloud and only paying attention to the word at the end of the sentence. Then Daneman and Carpenter (1980) conducted a study in which participants were asked to verify the validity of a sentence by responding true or false at the end of the sentence. Validation of the components in this experiment ensured that participants not only managed information but also processed information simultaneously.

Pashler, Harris, and Neuchterlein (2008) stated that when working on several tasks at the same time, bottlenecks can occur. This bottleneck case causes a decrease in performance on both tasks. Pashler, et al. (2008) found this to also be the case in a decision-making task in the Iowa Gambling Task. It was found that in blocks of dual-task trials, people were slower to make decisions than in blocks of control trials. Although there is evidence that people are slower at making decisions in dual-task trials than in control trials, the nature of the Iowa Gambling task makes it difficult to assess people's accuracy when making decisions in a dual-task paradigm.

Working memory has been shown to be related to many other constructs in psychology, such as comprehension (Daneman & Carpenter, 1980) and general intelligence (Jensen, 1998). This suggests that constructs involving a person's higher level processing are also related to the construct of working memory capacity. Brewin and Beaton (2002) found that people with high working memory spans were better at suppressing thoughts irrelevant to the task at hand than people with low working memory spans. The working memory span task essentially tests a person's ability to work on two tasks at the same time. So, people with high working memory spans are better at doing several tasks simultaneously than people with low working memory spans.

The research results of Ashcraft and Kirk (2001), Kane and Engle (2000) show that a person's working memory capacity influences his ability to carry out several tasks at the same time. The span task is built on the premise that people with greater working memory capacity are better at performing several tasks at the same time (Unsworth, et al.., 2005). When a person works on multiple tasks, each requiring working memory resources, competition for working memory resources occurs. The more difficult the task, the more resources are required (Ashcraft & Kirk, 2001).

Research conducted by Copeland and Radvansky (2004) also shows that people with small working memory spans use fewer strategies when working on reasoning tasks than people with large working memory spans. Knowing that people with large working memory spans use more complex strategies when performing tasks than people with small working memory spans, Beilock and DeCaro (2007) conducted research to determine the differences in strategy use between people with high working memory and people with low working memory in situations with different levels. pressure varies. Beilock, Kulp, Holt, and Carr (2004) illustrated that environmental stress can consume working memory resources, resulting in stress and tasks competing for working memory resources. Beilock and DeCaro (2007) found that when there was no pressure, people with low working memory spans used simple strategies while people with high working memory spans used more difficult strategies. In contrast, when there was situational pressure, both participants with high working memory span and participants with low working memory span used simple strategies.

Copeland and Radvansky's (2004) experiment showed that a person's working memory span indicates how difficult the strategy will be to use when working on a task. Beilock and DeCaro's (2007) experiments indicated that, when there is competition for working memory resources, high-span people perform tasks in the same way as low-span people. Therefore, when the task does not involve competition for working memory resources, high-span people may use more complex strategies than low-span people. However, when there is competition for working memory resources, high-span and low-span people use the same strategies.

Daneman and Carpenter (1980) argued that it is not measures of working memory that reveal differences in performance, but efficiency in stimulus processing. In other words, differences in performance are determined not by the amount of space available in working memory, but by how efficiently a person processes stimuli and the type of strategy used to perform the task. Efficient people use fewer resources to process tasks, whereas less efficient people use more resources to process tasks. Therefore, processing efficiency could be another reason that people with larger working memory capacities have the ability to use more complex strategies when performing tasks than people with smaller working memory capacities. This article will examine working memory and its impact on a person's ability to make decisions.

2. Methodology

The research conducted by the researcher was descriptive qualitative research. In this case, researchers looked for a relationship between students' working memory capacity and students' ability to work on integral material.

The location of this research was carried out at the Mathematics Education Study Program at Muhammadiyah University Enrekang (UNIMEN) for the 2022/2023 academic year. The collection techniques used are complex range assignments, written tests and interviews. The written test in this research is in the form of 6 numbers of Integral Material Test (TMI) questions. To measure students' working memory capacity, complex span tasks were used, namely the forward digit span task and the backward digit span task. Interviews in this study were conducted with one student who had a high working memory capacity and one student who had a low working memory capacity. The stages carried out by researchers in conducting this research include data reduction, data presentation and conclusions. In this data reduction stage, the researcher makes a selection in terms of completing student answers, at the data presentation stage, the researcher categorizes the test results on integral material questions and interview results, and in the conclusion stage, the researcher can conclude the relationship between students' working memory capacity and students' ability to work on questions. material about integrals by looking at the work process or student answer process.

3. Result and Discussion

The results of students' complex range assignments can be seen in table 1 and the results of students' Integral Material Test (TMI) can be seen in table 2 below:

Table 1: Results of Student Complex Range Tasks

No.	Name (Initials)	Forward Digit TRK Value	Backward Digit TRK Value	Final Score	Working Memory Capacity
1.	H	54	42	96	Low
2.	MI	53	50	103	High
3.	EAH	54	50	104	High
4.	K	69	33	102	High
5.	R	55	38	93	Low
6.	N	33	23	56	Low
7.	MA	43	41	84	Low
8	NOR	59	39	98	Low

Table 2: Student Integral Material Test (TMI) Results

No.	Name (Initials)	Value
1.	H	65
2.	MI	82
3.	EAH	92
4.	K	85
5.	R	68
6.	N	60
7.	MA	63
8.	NOR	67

From table 1 above, namely the results of students' Complex Range Tasks (TRK), we can see that there are 5 students who have low working memory capacity and 3 students who have high working memory capacity. For students who have low working memory capacity the names are (Initials) H, R, N, MA and NOR, while students who have high working memory capacity are named MI, EAH, K. Students are said to have high working memory capacity if they have a final score (The sum of the forward digit TRK value plus the backward digit TRK value) is more than or equal to 100 and students are said to have low working memory capacity if they have a final score (The sum of the forward digit TRK value plus the backward digit TRK value) is less than 100.

From table 2 above, namely the results of the students' Integral Material Test (TMI), we can see that H got a score of 65 out of a maximum score of 100, MI got a score of 82 out of a maximum score of 100, EAH got a score of 92, K got a score of 85, R got a score of 68 , N gets a score of 60, MA gets a score of 63 and NOR gets a score of 67 out of a maximum score of 100.

The Integral Material Test (TMI) scores obtained by students with the initials MI, EAH and K who have high working memory capacity are higher than the Integral Material Test (TMI) scores obtained by students with the initials H, R, N, MA and NOR who have low working memory capacity.

4. Conclusion

Based on the results and discussion above, we can draw a conclusion in this research, namely that there is a significant relationship between undergraduate Mathematics Education students who have high working memory capacity and Mathematics Education undergraduate students who have low working memory capacity in working on mathematics problems, where students who have High working memory capacity is more able to do integral questions correctly than students who have low working memory capacity.

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