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Students' Learning Outcome in Physics: Predictive Power of Split-Half Attention and Dual-Processing in Working Memory

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ABSTRACT
The study determined the predictive power of split-half attention and dual-processing in working memory on students' learning outcome in Physics. The population for the study comprised 5138 science students in public senior secondary schools. The sample was 650 SSII students currently offering Physics as a school subject in 22 secondary schools in the study area. Three sets of instruments used for data collection were Attention Lapses Clicker (ALC), Force Concept Inventory (FCI) and Cognitive Reflection Test (CRT). The instruments were face validated by three experts. Estimate of internal consistency was obtained through Kuder-Richardson (K-R21) for FCI with coefficient of internal consistency as 0.73. Data normalization was done using ZT-score and T-score. The data collected were analyzed using regression analysis to answer research questions and test null hypotheses at 0.05 level of significance. It was spotlighted that split-half attention as well as dual-processing in working memory had significant predictive power on students' learning outcome in Physics. Similarly, the combination of split-half attention and dual-processing in working memory had significant predictive power on students' learning outcome in Physics. Based on these findings, it was recommended among others that Physics teachers should guide students to gain control of attention and action to facilitate and mandate encoding of stimulus into working memory for enhanced learning outcome in Physics. The information selected for students to be held in working memory should be relevant to current objectives of instructional delivery to reduce split-half attention effect and enhance learning outcome in Physics.

Keywords: *Cognitive Load, Dual Processing, Working Memory*

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INTRODUCTION

a brain system responsible for temporarily storing and manipulating information. It functions as a mental workspace which can be flexibly used to support everyday cognitive activities. Those activities require both the simultaneous processing and storage of information. According to, performance on higher level cognitive tasks such as reasoning and reading are more accurately predicted by performance on working memory tasks compared to short-term memory tasks. Working memory is considered to have limited capacity. The memory span of young adults was around seven elements plus or minus 2. A minor distraction such as an unrelated thought springing to mind or an interruption by someone else is likely to result to incomplete loss of the stored information. Weak verbal working memory skills are also characteristic of poor performance on arithmetic.

Working memory plays an important role in Physics classes. Working memory can only hold and process so much information at one time and that time span is limited. Therefore, Physics teachers must make their lesson interesting and appealing to their students, the students must use this information which is temporarily stored in working memory to contribute in the class. found that the higher the students' mental workspace, the better and faster s/he makes contributions and the greater the proportion of correct answers. Conversely, the lower the mental workspace, the longer it takes for that individual to process information. An understanding of the capacity of the mental workspace based on split-half attention and dual-processing in relation to students' learning outcome has widespread implications for both practice and theory of education. This necessitates the current investigation.

This study is anchored on Sweller's cognitive load theory. The theory states that learning happens best under conditions that are aligned with human cognitive architecture. The structure of human cognitive architecture, while not known precisely, is discernible through the results of experimental research. Sweller's cognitive load theory is best applied in the area of instructional design of cognitively complex or technically challenging material. From an instructional perspective, information contained in instructional material must first be processed by working memory. For schema acquisition to occur, instruction should be designed to reduce working memory load. Cognitive load theory is concerned with techniques for reducing working memory load in order to facilitate the changes in long term memory associated with schema acquisition for enhanced academic potentiality of students.

The academic potentiality is a factor that determines the capacity of students to engage in educational task which requires higher cognitive functioning meaningfully. This could be tagged ability or level of academic attainment. Students' learning outcome is an important parameter in measuring students' attainment in Physics at secondary education level. It is commonly measured by assigning scores to all formative and summative assessments used by teacher in Physics class. Observation revealed clearly that no two students in Physics class are exactly the same in overall personality. This means that no individuals have equal potentials as far as learning is concerned because students may not have the same level of attention. The most dominant factor of value in any educational system, according to is students' learning outcome. That is why teachers use different forms of assessment in order to classify students into different ability levels based on their academic potentialities. The academic potentialities is improved by one's own goals and mental or overt actions, including response selection, action planning, protecting the pursuit of current goal from distractions and temptations, as well as switching from one task to another which is attention.

The meanings of the term attention are more diverse, as they reflect distinctions of definitions and different referents of the term. Attention is not a unitary entity.

Conceptualizations of attention can be distinguished along several dimensions. Attention is characterizes as a limited resource for information processing or a process or mechanism for selection of information to be processed with priority. These two concepts of attention play different roles in theorizing about working memory.

There is distinction between attention to our currently perceived environment such as attention to visual objects or auditory streams and attention to information currently not perceived, such as attention to remembered concepts that we think about in Physics. Likewise, there is distinction between attention to things and events in the world around us and attention to our own goals and mental or overt actions. The latter form of attention includes selection of our current goal or task set and shielding it from distraction, selection of one of several possible actions, and monitoring of our actions and their outcomes in Physics class. Similarly, there is distinction between controlled and automatic deployment of attention. Attention is controlled when it is directed according to our current goals.

The cognitive system has a limited resource that can be used for carrying out so-called attention-demanding processes. The resource is assumed to be a continuous quantity that can be split arbitrarily and allotted to different processes, depending on task demands. If two or more sources of information cannot be understood in isolation, then a split-half attention effect may occur. Split-half attention effect have been studied in instructional situations. These studies found that learning and transfer are both favoured by strategies that eliminate split attention in technical areas and conditional factors such as learner experience must be accounted for within a given knowledge domain. This is because processing efficiency, that is speed and accuracy, is a positive monotonic function of the amount of resource assigned to a process.

Dual processing theory refers to a collection of models in cognitive psychology that describe two systems of thinking: system 1, which involves intuitive and non-reflective thinking, and system 2, which is more deliberate and requires conscious effort and thought. System 2 enables us to solve complex problems, but tends to be slow and demands high concentration and computational power. System 1, on the other hand, is quick and requires low computational power, but is less suited to many tasks involving higher-order thinking. Humans have a strong bias towards system 1 processing, and are often described as cognitive misers. Students often demonstrate naive or intuitive ideas when answering Physics questions which are based on their experience of the world, but which, from a scientific perspective, are incorrect. These incorrect answers are often referred to as misconceptions. Misconceptions are viewed as ideas that are likely to hinder learning.

There is a debate about the role that misconceptions play in learning Physics. This is important because how misconceptions are viewed affects approaches to teaching. The existence of misconceptions hindered the progress of learning in Physics class and reduced students' learning outcome. Misconception is learners' opinion that is incorrect because it is based on faulty thinking or fraud understanding. It is however expected that formal instructions in Physics should lead to the modification, reduction or even adjustment in students' misconceptions because effective teaching should not only edify students on what is correct, it also ensures that students do not believe what is incorrect. The issue of students' misconceptions in Physics in secondary schools is a major problem that befalls the educational sector. The teaching of Physics should therefore be focused on challenging these misconceptions through conceptual change for effective and efficient learning. Dual processing theory may provide an alternative approach to understanding the role of misconceptions in learning Physics. Students can benefit from the teacher who motivates and possess theoretical and pedagogical content knowledge from the way he/she delivers instruction which could boost their learning outcome in Physics. The Strength of the current study lies with the inclusion of the measure of the predictive weight of students' split-half attention and dual-processing in working memory alongside learning outcome in Physics. Therefore, the objectives of the study are to:

- Determine the predictive power of split-half attention on students' learning outcome in Physics.
- Determine the predictive power of dual-processing on students' learning outcome in Physics.
- Determine the joint predictive power of split-half attention and dual-processing on students' learning outcome in Physics.

RESEARCH METHODOLOGY

A correlational survey research design was adopted for the study. The study was conducted in Otukpo, Ohimini and Apa Local Government Areas of Benue State. The population for the study comprises 5138 science students in the public senior secondary schools in the study area. The sample for the study was 650 SSII students currently offering Physics as a school subject in 22 public senior secondary schools in the study area. The sampled schools were drawn using purposive sampling technique. This is because purposive sampling enables the researcher to select those schools that satisfy certain requirements and criteria critical to the research objectives.

The instruments for data collection are Cognitive Reflection Test (CRT), Force Concept Inventory (FCI) and Attention Lapses Clicker (ALC). The CRT is a three item instrument used to measure students' tendency to engage in the two systems of thinking: system 1 and 2. Devised by [19], the CRT has been used particularly for assessing intuitive-analytic cognitive styles [20]. The three questions used in the standard CRT were adapted. Each question on the CRT is designed to reliably cue an intuitive, but incorrect answer. The CRT therefore measures the tendency to override an initial, intuitive answer (system 1) and then to engage in more reflective thought (system 2) to determine the correct answer. The CRT is used to measure dual-processing in the working memory. The FCI is a 30 item multiple-choice test designed by [21]; and updated in [22]. It gives a measure of students' conceptual understanding of Newtonian mechanics. The test builds on the work of [23] which found that common sense beliefs about motion had a large effect on performance in Physics. The FCI is used to measure students' learning outcome in Physics.

The Attention Lapses Clicker is an instrument used to detect attention deficit in the working memory. Using the Attention Lapses Clicker (ALC), the students were asked to report attention lapses by pressing a button on their clickers after they became aware that they had experienced a period of inattention. The students clicked one button to indicate an attention lapse lasting 1 minute or less, another button to indicate a lapse of 2 to 3 minutes, and a third button to indicate a lapse of 5 minutes or more. The clicker-responses were sent to a computer, and this information was mapped onto a timeline and used to measure the average length of the students' reported attention lapses. The Attention Lapses Clicker (ALC) was used to determine students' split-half attention effect in Physics class. The instruments were face validated by expert in Measurement and Evaluation, Psychology Education and Physics Education

RESULT AND DISCUSSION

Respectively all from Science and Mathematics Education Department, Benue State University, Makurdi, Nigeria. Estimate of internal consistency was obtained through Kuder-Richardson (K-R_{21}) for Force Concept Inventory. The internal consistency estimate was found to be 0.73 for FCI. The instruments were administered by the researchers with the assistance of the regular Physics teacher in each of the sampled senior secondary schools. Two weeks was used for data collection. Permission was sought from the school management to administer the instruments. Data normalization was done using Z_T-score and T-score. The raw scores obtained in each subject was first converted to Z-score then added to obtain the Z_T-score for each student. The Z_T-score was then converted to T-score. The continuous data collected were measured to interval level and analyzed using regression analysis to address the research objectives and test significanceat 0.05 level.

The data were analyzed and presented in tables to aid comprehension. Regression analysis is applied in the present study since it has the capacity of predicting outcomes. The reason is that, if a regression model can be generalized, then it must be capable of accurately predicting the same outcome variable from the same set of predictors with different group of people. If the regression model is applied to a different sample and there is severe drop in its predictive power, then the regression model clearly does not generalize. Regression analysis also shows how Table 1 shows the summary of stepwise regression analysis of split-half attention and dual-processing in working memory on students' learning outcome in Physics. The analysis reveals that the correlation between split-half attention and students' learning outcome in Physics is 0.537 with a coefficient of determination is 0.288. This implies that 28.8 percent of the variation in students' learning outcome in Physics can be attributed to split-half attention in the working memory. The analysis implies that the predictive power of split-half attention in working memory is 0.048. The table further shows that the probability associated with the calculated value of t(0.067) is 0.00. Since the probability value of 0.000 is less than 0.05 level of significance, split-half attention in working memory had significant predictive power on students' learning outcome in Physics.

Table 1 again shows that the correlation between dual-processing in working memory and students' learning outcome in Physics is 0.337 with a coefficient of determination is 0.114. This implies that 11.4 percent of the variation in students' learning outcome in Physics can be accounted for by dual-processing in working memory. The analysis implies that the predictive power of dual-processing in working memory is 0.117. The table further shows that the probability associated with the calculated value of t(0.442) is 0.00. Since the probability value of 0.003 is less than 0.05 level of significance, dual-processing in working memory had significant predictive power on students' learning outcome in Physics.

A. Predictive Power of Split-Half Attention on Students' Learning Outcome in Physics

The finding of the study revealed that split-half attention in working memory had significant predictive power on students' learning outcome in Physics. This implies that split-half attention effect in the working memory is a determinant of students' learning outcome in Physics. This might result from students' action planning, protecting the pursuit of current goal from distractions and temptations, as well as switching from one task to another. The necessary ingredients of split-half attention is the intentional selection of the contents of working memory, controlled by mechanisms of filtering out irrelevant stimuli and removing no longer relevant representations from working memory. This is because within working memory contents, a single item is often selected into the focus of attention for processing. What is of great concern about split-half attention effect is the contribution of working memory in cognitive control of perceptual attention. This is achieved by holding templates for targets of insightful selection and controlling students' approaches to problem-solving in Physics class by holding task sets to achieve stated behavioural objectives.

The finding is in agreement with earlier findings of that striking similarities between the capacity limits for attending to perceptual stimuli and for maintaining stimuli in memory and that these two functions could rely on separate resources that happen to bear similarities to each other. If the same limited resource underlies perceptual attention and maintenance in working memory, then demanding both at the same time should incur a substantial dual-task cost, such that when the load of one task is increased, performance on the other suffers. The finding is also in conformity with earlier findings of [25] that the contralateral delay activity amplitude increased with set size up to about 3 items and then levelled off. Individual contralateral delay activity amplitudes correlated with performance on a test of one randomly selected item regardless of whether that item remained in view until the time of test or had to be retained in memory for a second. The finding is also consistent with earlier findings of [26] that only negligible dual-task costs when inserting a visual attention task (monitoring a stimulus for a subtle brightness change) in the retention interval of a visual working memory task. However, the finding disagrees with that of [2] that there is no significant relationship between students' measure of attention span and problem-solving skills of low cognitive ability level in science.

B. *Predictive Power of Dual-Processing on Students' Learning Outcome in Physics*

The finding of the study showed that dual-processing in working memory had significant predictive power on students' learning outcome in Physics. This means that dual-processing in working memory is a determinant of students' learning outcome in Physics. This might be due to the fact that a dual-processing in working memory combines aspects of both knowledge as theory and knowledge in pieces perspectives. The students' intuitive ideas developed from experiences of the world are likely to be deeply ingrained and could therefore become heuristics that are adopted as system 1 responses. This may explain why some misconceptions seem to be common and universal among students at secondary school level. Students who tend to be cognitive misers are found to be more apt to answer Physics questions with their intuitive ideas. However, students who are found to be able to override these intuitive responses and to engage in system 2 thinking are much more likely to activate appropriate Physics resources to enable them answer question correctly in Physics class. Activation of resources can therefore be seen as something that is dependent on both the context of the problem and the individual characteristics of the students. Although clearly more research is needed, this result has important implications for the way the nature of student difficulties with Physics are thought about.

The finding concurs with the earlier findings of [27] that students held different misconceptions about cultural belief and values which they take into the classroom. The finding also concurs with the earlier findings of [18] that students' misconceptions significantly predicted academic engagement in Physics. However, the finding disagrees with that of [18] that students' misconceptions do not significantly predict retention in Physics.

C. *Joint Predictive Power of Split-Half Attention and Dual-Processing on Students' Learning Outcome in Physics*

The finding of the study further revealed that split-half attention and dual-processing in working memory jointly significantly predicted students' learning outcome in Physics. This implies that the combination of split-half attention and dual-processing in working memory is determinant of students' learning outcome in Physics. The joint significant predictive power of split-half attention and dual-processing in working memory on students' learning outcome found in the present study suggests that performance is also enhanced by an increase in germane cognitive load capacity. The study found support for selecting information to be held in working memory, but that it is not necessarily selection of one piece of information at the exclusion of all others. Students in Physics class often hold multiple separate items in working memory simultaneously. Sometimes the students have to select a single item from the set currently held in working memory as the input for a process, or as the object of mental manipulation. The students' ability to select individual items from the set currently held in working memory such that the two or more sources of information which cannot be understood in isolation are filtered successfully may enhance effect of split-half attention.

The finding that the normalized students' learning outcome is reliant of dual-processing in working memory raises further questions about the role of misconceptions in learning Physics. The study found that students who are likely to rely on system 1 thinking and therefore to choose the intuitive option, as measured by the CRT, see a similar improvement in conceptual understanding as students who override their intuitive ideas and engage system 2 thinking. This result implies that even though misconceptions in the form of common intuitive ideas seem to exist, they do not hinder the development of more scientific views of the world. This is responsible for the significant predictive power of the combination of split-half attention and dual-processing in working memory on students' learning outcome in Physics. The implication of a dual-processing theory perspective for Physics instruction is the idea that misconceptions are deeply ingrained intuitive ideas that are activated through system 1 thinking, without conscious thought imply that students should be helped to develop the cognitive reflection skills necessary to override system 1 and to engage in system 2 thinking. Again, the implication is that rather than challenging misconceptions, teaching should focus on building connections between scientific ideas, so that appropriate resources can be more readily activated. Although more work is clearly needed, it is believed that a dual-processing perspective has the potential to further our understanding of learning in Physics. The finding is in conformity with earlier finding of [28] that students in five European countries have similar misconceptions about simple electric circuits. As such, the students held erroneous beliefs or alternative views of scientific principles or wrong notions about certain scientific concepts.

CONCLUSION

Based on the findings of this study, it was concluded that split-half attention in working memory, dual-processing in working memory as well as the combination of split-half attention and dual-processing in working memory are determinants of students' learning outcome in Physics. The successful leveraging of split-half attention and dual-process in working memory mechanisms in this study suggests a possible pathway to develop the skills needed to overcome an incorrect default model cued by a salient distracting feature. Based on the findings of the study, the following recommendations were made:

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