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The influence of smart phone over-dependence on the recall of basic mathematics among mathematics education students in a Nigerian university

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ABSTRACT

Recent decades have seen dramatic increase in the amount of technology available to and used by children, a fact that has clearly shaped the way children learn mathematics. An unintended outcome of technology integration in mathematics education is the growing dependence among students on the internet as a source of information previously committed to memory. This study employs a simple survey to determine how the ubiquity of smart phones among mathematics education students influence their ability to recall basic mathematics concepts. Structured Basic Mathematics Recall Task (BMRT) and Smart phones Influence on Mathematics Recall Questionnaire (SIMRQ) were developed for the study and administered to a random sample of 180 mathematics education students. Simple percentages and means were used to analyze the data the data obtained from the BMRT and SIMRQ. The outcomes of the study indicate that 46.7% of mathematics education students could correctly recall formulas and values of basic mathematical constants, 31.6% could correctly provide the statement and definition of basic math concepts, and 28.3% could correctly tell when to use a particular formula under specific conditions. The results of the study reveal that processes of human memory are adapting to the advent of digital technology, with students displaying low recall of foundational facts and high impatience to quickly rush to the internet in quest of information previously memorized. The findings of this study points to the fact that true mathematical prowess in the current age is only achievable through the conscious effort of the learner in internalizing basic mathematical concepts and regular practice of learnt facts. Based on the findings, it was recommended that students should be guided through measured technology integration in mathematics instructional delivery to avoid over-dependence on technological tools.

Keywords: Mathematics, Memory, Memory augmentation, Digital amnesia, Mathematics prowess

1. INTRODUCTION

Mathematics plays a key role in shaping how individuals deal with the various spheres of private, social, and civil life. The knowledge and application of mathematics made it fundamental to all facet of human endeavour. The relevance of the subject has position it as a compulsory subject in Basic Education and a foundational course in virtually all professional fields of study. Thus, mathematics is a part of children's life experience.

Simply stated, the main goal of mathematics education is the mathematics child's thought processes (National Council of Educational Research and Training -NCERT, 2006). Clarity of thought and pursuing of problems in a systemic manner is central to the mathematical enterprise. The target of educational efforts anywhere in the world is to develop life skills and link schooling to livelihood. This explains why the school system deliver instruction to enable children use abstractions to perceive relationships, to understand the basic structure of mathematics, and to appreciate the scope and power of mathematics in inculcating the right habits of thought and communication.

The expectation, generally, is that as mathematics advances, learners incorporate it into their thinking. As their thinking becomes more sophisticated, they generate new mathematical concepts and new mathematical structures (Thurston, 1994). Evidently, the subject matter of mathematics changes to reflect how people think and eventually recall basic facts.

As children grow older and make progress up the educational ladder, mathematics learning will make no sense if it is a remarkable mental process and a mental system which receives information from stimuli, retains it and makes it available on a future occasion. Memory provides continuity in experiences across deferent time points. This continuity is a fact on which the entire educational process hinges, with knowledge and skill taught at incrementally spiral levels. Mathematics in particular is structured in a way such that present learning is built on the foundations of past learning experiences. An outcome of this spiral structure is the persistent need to recall foundational facts, theorems, axioms, and associated formulas every now and then.

Memory and remembering in particular has been shown to be a constructive process, with recall being a combination of retrieval and reconstruction. Information tends to evaporate with time unless it is actively maintained (Altmann & Gray, 2002). With respect to the study of mathematics, fundamental prowess in recall and application of mathematical facts is more a function of practice than of time. Forgetting of basic mathematical concepts is now being felled by several side attractions of the current age in which focus and attention are in limited supply, especially among youngsters.

It is quite obvious that the invention of computers has turned human existence into an information-ruled one (Iji, Abah & Uka, 2013). Digital technologies are revolutionizing human thinking and opening up access to whole lot of possibilities in the education sector. Schools all over the world are becoming an integral part of the broadband and technology transformation, harnessing the potentials of technology to drive and empower more personalized horning. Despite the benefits accruing from the availability of digital technologies, over-dependence on them turns out to be bad for children's mathematical memory. This over-dependence, according to Felt and Robb (2016) can lead to technological addiction.

The tendency to rely heavily on information available online instead of tasking ones memory is currently on the increase. The enormity of this perspective of technological dependence was brought to the light in a recent quantitative study commissioned by the cyber-security firm, Kaspersky Lab. People, including students of mathematics, rely on the internet and internet-enabled devices such as smartphones to connect them to a vast repository of knowledge, anywhere anytime (Kaspersky Lab, 2015). With the unending reach of instant search engines, students tend to relinquish the duty of simple recall of core mathematical concepts to digital technologies. This growing trend poses real danger to the preservation and transfer of the mathematical culture inherited by the present generation.

Digital Amnesia is the experience of forgetting information that one trusts a digital device to store and remember for him (Kaspersky Lab, 2015). This present study seeks to find out how the ubiquity of smart phones among mathematics education students influences their ability to recall basic mathematical facts, theorems, axioms, and formula. What prospect does the observed phenomenon hold for the quality of mathematics teachers produced from Nigerian higher educational institutions? What are the expected long-term implications for mathematics education in general?

Literature review

Mathematics is seen as the study of patterns of structure, chance, and space. Mathematics is a language of symbols, technical definitions, computation, and logic (Thurston, 1994). Simply put, mathematics is the study of figures and numbers. It is the investigation of axiomatically defined abstract structures using logic and mathematical notation.

There is no doubt that mathematics is of immense practical value in life. We regularly use mathematics in our everyday life: from measuring distances and weights to reading timetables and in estimation (Legner, 2013). Mathematics is essential for full comprehension of technological and scientific issues.

As a subject, mathematics is full of automatic procedures that have to be mastered (Iji, Abah & Uka, 2013). As an outcome, school mathematics attaches emphasis to factual knowledge, procedural fluency and conceptual understanding (NCERT, 2006). A relevant curriculum and pedagogy of mathematics focus on a whole range of processes, including formal problem solving, optimization, use of patterns, visualization, reasoning and proof, making connections, and mathematical communication. Generally, the aim of teaching mathematics includes the development of good understanding of numbers and the number system, improving speed in understanding relationships, achieving rapid mental recall of facts, developing the ability to solve problems, and improving skills in decision making.

Learning mathematics entails building up a database of concepts, abstraction, generalization, and applications. This is why mathematics is taught incrementally on basic foundations of rules, axioms, theorems, and formula. Burgin (2000) observes that these foundations provide means, concepts, structures, and methods for the development of the whole mathematics, or at least, of its major part. Most of these foundational rubrics as found in named sets theory require the students to imbibe fundamental mathematical knowledge as an indispensable companion in life.

Mathematics is proud of its history, confident in its tradition, and certain that the truth it pronounced are real truths applying to the real world (Wells, 2006). Such real world applications are made possible by years of accumulated and structured facts, taught in school to children as the subject of mathematics. Evidently, mathematics can be seen as the act and science of proving theorems, and a theorem is a statement that, given the premises laid down by the axioms and certain agreed upon rules of inference, is apodictically true. The mathematics taught in school is the interconnections between several of these facts and one of the objectives of teaching the subjects is to raise the aesthetic value of its culture, stimulate curiosity, create enjoyment of mathematics, and develop children depth of understanding (Massachusetts Department of Elementary and Secondary Education, 2011).

The nature of mathematics requires students to articulate sound mathematics explanations and always justify their solutions (Anthony & Walshaw, 2009). Years of schooling are expected to instill mathematics confidence in students and build in them the capacity to persevere in the face of mathematical challenge. With the emergent paradigm of the pedagogy of mathematics, focus is shifting from crude memorizing of algorithms and computations to mathematical intuition, mathematical thinking and real-world problem solving (Legner, 2013). In this perspective, recall of simple mathematical facts should come in handy for students irrespective of technological interference.

Memory is basically a store of things learned and retained from an organism activity or experience as evidenced by modification of structure or behaviour or by recall and recognition (Merriam-Webster, 2016). Learning will make no sense if it is not retrained since the capacity of the memory is the only means a person can relate to different events, experiences, conditions, people and objects. Memory makes it possible to operate beyond the constraints of time and place.

The human memory system receives, encodes, modifies, retains and retrieves information. Encoding refers to the translation of incoming stimulus into a unique neural code that a person's brain can process while storage is the retention of the material encoded over a period of time. Retrieval is the recovery of the stored or retained information at a later occasion.

A general model of the human memory depicts three distinct types of memory, namely, sensory register, short term memory and long-term memory. The sensory register is the first point of interaction of the memory system with information gathered through the senses. It holds information for a short duration before passing the information onwards. It occurs within the sensory system while the message is being transmitted to the brain.

The short-term memory is the working memory. It holds immediate visual images, sounds, words and sentences before transmitting them to the long term memory. The sensory memory and short term memory are limited in terms of duration. The long-term memory is a relatively enduring memory in which information is stored for use at a later time. Meaningful verbal materials and life events that are acquired in the course of experiences persist in the long term memory and are often retrieved into the working memory for usage.

Information retained in the memory is subject to change and modification. Forgetting is failure to recall information stored in memory. Myers (2007) sees forgetting as the inability to retrieve information, due to poor encoding, storage or retrieval. Many causes, and factors and theories of forgetting have being propounded by a wide range of psychologist over the years. The common list of factors or causes comprises decay of memory traces interference, motivations, retrieval failure, misinformation and imagination effects, and amnesia. However, Wixted (2004) observes that these common points of view have changed in recent times from a theoretically coherent interference-based account to a theoretical laundry list of factors that may or may not play a role. Arguably, high levels of practice and usage of stored fact enhance effective retrieval for future usage (Altmann & Gray, 2002).This truth holds particularly in mathematics where performance is evidently related to practice.

One of the crucial lessons emanating from any casual review of literature memory is the role of interest and sound background in the subject area. Learners who show interest in the particular subject area tends to recall information better. Also the more background the learner has in a subject, the better he can form associations and discern relationships between the new and the old information (May & Einstein, 2013). This is particularly emphatic for the recall of mathematical facts in later years by students as the gradually advance in their studies. Poor recall of information considered simple and fundamental mathematics maybe a pointer to something deeper than forgetting. It may indicate a new dimension of high- handedness on the part of students and may reveal underlying altitudinal issues in mathematics education.

Memory is often defined as the application of learning over time (Mays & Einstein, 2013). It establishes links across different learning experiences. Memory is needed in developing social relationships, mastering cognitive competencies and solving various problems. The indispensability of a good memory makes forgetting appear to be a fatal failure (Connerton, 2008).

The need to sustain steady recall leads to augmentation. Basically augmentation is complimentary measure meant to support a falling or an inadequate system. Augmentation ranges from simple memory enhancing strategies such as mnemonics and memory aids to information on the internet. The wide range of available technological operations only underscores the assertion that learning experiences today are defined by the pervasive influence of digital technology (Bavelier, Green & Dye, 2010).

People willingly accept technological augmentation to ease the demand of recalling vast amount of information. The Internet is now being used as an extension of the brain (Kaspersky Lab, 2015). Presently, the available body of evidence has not being able to establish whether Internet use is creating a generation with fundamentally different cognitive skills (Mills, 2014).But there are suggestions that being a part of highly connected network can help individuals solve problems by facilitating the propagation of correct information. Conclusively, the effect of internet use on cognition can likely nuanced, but could strengthen specific cognitive strategies in young adult, if carefully articulated into existing framework.

The Internet, with its search engines such as Google and online databases has become an external memory source that people can access at any time (Bavelier et al, 2010). Social network services like Facebook are increasingly turning to information repositions forming a digital bridge for those afraid of swiftly loosing fond memories. A most recent upgrade to the service of face book, for instance, has open up an educational front in which users can save interesting web pages and contents to their timeline on the social networking giant by simply clicking a save-to-Facebook button to be made available on third party sites and services. These saved materials will permanently be available for referencing by the users as long as their Facebook accounts exist.

Iji, Abah and Anyor (2014) rightly noted that cloud technology integration in mathematics education has resulted in the transformation of young minds known for a culture of learning, leisure and social interaction. Documents and memories pushed into the cloud on smartphones are easily accessible by students many years after. But a serial habit of relying on this cloud-sourced memory is resulting in a sense of over-dependence on augmentation at the detriment of personal cognitive efforts.

Memory and learning are two different processes that are closely related. Learning refers to the acquisition of new behaviour through experience that has persisted in memory. Memory is a skill that can be improved upon the limits of one's potential. The formation of concrete memory is often hampered when the content to be retained is not correctly, clearly, and forcibly impressed on the mind. If mathematical knowledge is approached with anything less, learning will be hardly achieved. The over-dependence on an external memory source builds an attitude among learners that is devoid of necessary attention and interest. This attitude eventually leads to disuse of learned mathematical concepts resulting in gradual effervescence of retained mathematical knowledge (Mills, 2014).

Based on the Kaspersky Lab (2015) research, it can be argued that the trend to look up information before even trying to recall it prevents the build-up of long-term memories, and thus makes people process information merely on a shallow, moment-to-moment basis. This outcome is a threat to mathematical posterity. The future will indeed be uncertain if mathematical creativity is abandoned in favour of mathematical referencing. Having online access to search engines, databases, and the like, is fast becoming a primary transitive memory source in itself (Sparrow et al, 2011), with students getting more interested in "where" information can be obtained than "what" the content of such information is.

The resulting trend and outcome of technological interference in concrete mathematical learning have upset the expected order of mathematical development in children. Through-out the early years of life, children notice and explore mathematical dimensions of their world. They compare quantities, find patterns, navigate in space, and grapple with real problems (National Association for the Education of Young Children –NAEYC, 2010). Mathematics helps children make sense of their world and helps them construct a solid foundation for success in life. In life, students need mathematical proficiency and understanding to make informed decisions and make progress. This is the natural pathway to mathematical prowess –a phenomenon that is currently being challenge by an inadvertent relinquishing of effort to easily accessible internet connections.

Children's confidence, competence and interests in mathematics flourish when new experiences are meaningful and connected with their prior knowledge and experience. Lack of proper connection to explicit concepts learnt earlier sometimes prevents students from making full use of retained knowledge (NAEYC, 2010). These connections and explicit formulation is the formalization of mathematics as taught in schools. Hatcher (2008) maintains that everyone agrees that mathematical activity involves the following processes: contemplation of abstractions, the generation of mental construction, and the explicit formulation of rules of symbolic manipulation. The process of attaining mathematical prowess requires active participation on the part of the learner to internalize mathematical knowledge.

A proficient mathematician is a master of critical thinking, of analysis, and of deductive reasoning (Krantz, 2007). These skills travel well and should be bankable, particularly by prospective mathematicians who are being grilled to stand out with the use of rigorous proofs and further the timelessness of the subject of mathematics. Sparks (2006) maintains that it is partly through memorization that we eventually become "unconsciously competent", a true master of our skill, practicing it in an almost effortless, automatic sense. Knowing basic facts and understanding the reasoning behind them propels one towards the road to mathematical fluency, so essential in our modern high-tech society.

Research Questions

The following research questions were raised to guide the study.

1. What percentage of mathematics education students correctly recalled basic mathematical facts?
2. How does the ubiquity of smartphones among mathematics education students influence their ability to recall basic mathematical facts?

2. METHODOLOGY

Simple survey research design was employed in this study to investigate how the ubiquity of smartphones among mathematics education students influences their ability to recall basic mathematical facts. Mathematics education students from the three mathematics education programme options of B.Sc.(Ed) Mathematics/Computer Science, B.Sc.(Ed) Statistics/Computer Science and B.Sc.(Ed) Mathematics/Statistics, offered at a federal University in North Central Nigeria, were used for the study. The population of the study comprises the 1218 mathematics education students. Specifically, a random sample of 180 second-year (200 Level) mathematics education students across the three options were used for the study. The choice of the class was along the line of reasoning that second-year students are at the middle of their degree programmes and yet not very far from their secondary school backgrounds where basic mathematical concepts were explicitly learnt.

Mathematical concepts considered in this study are foundational axioms and formula such as Pythagoras theorem, sine and cosine rules, basic axioms in set theory and a few definitions. These were built into the researcher-developed Basic Math Recall Task

(BMRT) and the Smartphones Influence on Math Recall Questionnaire (SIMRQ) instruments. The SIMRQ is structured on a four-point scale with Strongly Agree (SA=4), Agree (A=3), Disagree (D=2), and Strongly Disagree (SD=1). It comprises nine (9) items to elicit responses in relation to perceived performance in on the BMRT. As such, the BMRT was administered to respondents before the SIMRQ.

The two instruments used for this study were validated by three (3) experts in mathematics education from the University of Agriculture Makurdi, Nigeria. The experts' corrections, opinions and suggestions were used to restructure the items in terms of suitability and relevance, increasing an initial effort of 8 items to a final output of 9 items for the SIMRQ. The reliability analysis of the SIMRQ yields a Cronbach alpha coefficient of 0.74, indicating a high level of internal consistency for the instrument.

3. RESULTS AND DISCUSSIONS

The result of analysis carried out on data obtained with the Basic Recall Task (BMRT) and Smartphones Influence on Math Recall Questionnaire (SIMRQ) are presented here in respect to the research questions.

Research Question One: What percentage of mathematics education students correctly recalled basic mathematics facts?

Table 1 Recall on BMRT

S/N	Basic Math	Formulae/Value	Statement/Definition	When to Use
1	Pythagoras Theorem	73%	68%	45%
2	Sine Rule (Law of Sines)	43%	22%	10%
3	Cosine Rule (Law of Cosine)	36%	13%	7%
4	DeMorgan's Law	27%	20%	18%
5	Quadratic Formula	47%	32%	30%
6	Distance from A to B on straight line	23%	19%	Not Applicable
7	Mid-point of the Segment $\overline{A}$	31%	25%	Not Applicable
8	Slope of a Straight Line	89%	52%	46%
9	Volume of a Cylinder	34%	29%	Not Applicable
10	nth term of GP	62%	60%	55%
11	Quotient Rule (calculus)	48%	44%	40%
12	Product Rule (calculus)	51%	50%	43%
13	Heron's Formula for Area of Triangle	41%	26%	15%
14	Golden Ratio	3%	3%	Not Applicable
15	Simple Interest	87%	81%	Not Applicable
16	Persistence (Multiplicative)	Not Applicable	9%	Not Applicable
17	DeMoivre's Theorem (Complex Numbers)	2%	2%	2%
18	Derivation of pi (π)	97%	14%	Not Applicable
	Average Value	**46.7%**	**31.6%**	**28.3%**

The results in Table 1 shows the percentage of mathematics education students who correctly recall a set of randomly selected basic mathematical fact by clearly stating the required formulae/value, statement/definition, and when the particular item is should be used. The overall report indicates that 46.7% of mathematics education students could correctly recall formulas and values of basic mathematical facts, while 31.6% of mathematics education students could correctly provide the statement and definition of basic math concepts/facts. 28.3% could tell when to use a particular formula and could state specific conditions.

The overall averages from the items in Table 1 fall short of the expected 50%. There seem to be a downward trend when it comes to providing details about basic mathematical concepts, pointing out that possibly students did not properly internalized the concepts even at the time they were taught. This poses a great danger to the students' growth and development when considered along the perspective of Willingham (2010) who emphasized that automatic retrieval of basic mathematics concepts from memory is critical to solving complex problems since complex problems have simpler problems imbedded in them.

Research Question Two: How does the ubiquity of smartphones among mathematics education students influence their ability to recall basic mathematical facts?

Table 2 Analysis of Responses on SIMRQ

S/N	Items/Statements	Mean	Remark
1.	I have been taught most of the basic maths concepts before.	3.12	Accepted
2.	I used to easily recall mathematical facts better in the past than now	2.5	Accepted
3.	I actually thought I would recall better if I had the chance to "ask Google".	3.24	Accepted
4.	It is impatience to quickly rush to the internet for information one has previously memorized.	3.37	Accepted
5.	Under a different situation I would have checked for the correct answers on my smartphone even before "stressing my head".	3.65	Accepted
6.	Except when preparing for a test or an exam, I quickly check on the Internet when confronted with basic math problems	2.71	Accepted
7.	Students tend to remember less basic math facts knowing they can always depend on their smartphones.	3.16	Accepted
8.	I consider over-dependence on the Internet for simple recall a threat to the future of mathematics knowledge.	3.18	Accepted
9.	I believe a conscious effort to understand math is better for me than depending on technology all the time.	2.94	Accepted
	Grand Mean	3.10	

Table 2 above shows an acceptance (grand mean = 3.10) among respondents that they often depend on technological augmentation for simple recall. Respondents also accepted that the phenomenon poses a great danger to the future of mathematical knowledge. They supported the belief that proper learning of mathematical content is more reliable than outright dependence on technology.

4. CONCLUSIONS

This study has attempted to demonstrate the impact of over-dependence on digital communication gadgets on students' memory efficiency in mathematics. The pattern of students' ability to recall basic mathematical facts, theorems, axioms, and formula indicates a negative influence of smartphone over-dependence on simple recall. The participants of this study accepted that over-reliance on the Internet for simple recall poses a great threat to the future of mathematical prowess.

The findings of this study clearly support the outcome of the Kaspersky Lab (2015) survey in affirming that mathematics education students tend to rely heavily on the Internet and Internet-enabled devices such as smartphones to connect them to the vast repository of knowledge, anywhere anytime. There is indeed a waning desire to properly commit learning to memory due to the ubiquity of smartphones and their ever-present internet connectivity. This growing dependence on the internet as a source of information we might previously have memorized or looked for elsewhere can reflect impatience or the need for speed in a fast-moving world. It can be argued that if we preferably use our smartphones to off toad currently irrelevant information so we can access it again at a later time when necessary, interference with the learning of new information can be greatly reduced. In this way, dependence on memory augmentation will be justifiable without rendering the human memory redundant and passive. The act of memorization in mathematics is a skill which must be developed and sustained for the very survival of mathematical prowess.

Recommendations

In view of the findings of this study, the following recommendations are made:

1.The teaching and learning of mathematics at the foundational level should be given adequate attention with focus on conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Children should be made to practice simple routines such as "borrow and regroup" to foster the learning of the sequence of steps by which a frequently encountered problem can be solved. To build the strands of mathematical proficiency, children can be guided to count successfully before they understood all of counting's properties, such as the irrelevance of order. A productive disposition could be enhanced in students when mathematics teachers adopt methodologies that integrate the use of modern tools that exploit a variety of self-regulation strategies and drive individualized learning.

2.Children should be guided through measured technological integration in mathematics instructional delivery to avoid over-dependence on technology. Technology deployment does not always help learning – it sometimes impedes it. This is most likely when technological tools are so visually interesting that they distract from their purpose or when their relationship to the concept to be represented is obscure.

3.Teachers of mathematics at the early childhood and basic education levels should stimulate in children an aesthetic value of the subject to enhance sustained interest of the subject. This can be achieved by deploying instructional materials such as manipulatives and concretizing abstract terms through vivid analogies. For instance, a teacher might teach students that algebraic equations may be thought of like a balance scale. The two sides are equivalent and their equivalence can be maintained so long as one perform the same operations on both sides,

4.In teaching procedural and factual knowledge to young adults, schools should ensure students get to automaticity. Current efforts of the National Mathematics Centre Abuja to resuscitate Mental Arithmetic should be supported and transferred to all schools within the Basic Education level for the full development of the Nigerian child.

5.At the university level, the teaching of mathematics should cultivate greater conceptual knowledge as well as emphasize procedural and factual knowledge. Mathematics teachers at this level should never assume their students are already abreast with some vital mathematical concepts. Even at this level, depth matters the more.

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