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Remedial Process for Negative Numbers Subtraction Operation: A Computerized Diagnostic Assessment

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Abstract **— This study is a part of our research on remedial process for Negative Numbers subtraction operation. It was based on our previous study which involved 124 students aged 14 years old and five Mathematics teachers from secondary schools from a district in Malaysia which identified a diagnostic assessment for subject domain. It was found that conventionally to implement such diagnostic assessment in school setting was possible but the time and work load to analyse and make visual the misconceptions information was impossible as the sample size increases for mathematics teachers. Thus, this study was about computerization of that diagnostic assessment which would enable students to analyse their own ability in subject domain at anytime and anyplace. This system provides immediate analysis result which would save time and work load of remediation process and repeated as many times as each students wants to and be more responsible in monitoring their own misconception based on the analysis result obtained.**

Keywords **— Visual Informatics; Computerization; Diagnostic; Remedial; Subtraction; Negative Numbers.**

I. INTRODUCTION

According to [1], the Lower Secondary Examination (PMR) report from the Malaysian Examination Board shows that students were unable to master the skills and understanding the abstract concepts that involves negative number operation in fraction, transformation and algebra. Moreover, in the 2002 among the Malaysian student who sat for the PMR examination, 47% showed clear weaknesses in operation involving negative number such as (-17+14), (-17+22+8), (-17-14) and (-17+30) [2]. Such that, a study with 124 students aged 14 year from two secondary schools in Malaysia was carried out by [3] which revealed the existence of difficulties in solving negative numbers subtraction operation involving two integers. This phenomenon is explained by [4] as situations whereby negative numbers extend our number line and greatly simplify our calculations, but sometimes students struggle with the concepts. Nevertheless, according to [5], it is also important for students to determine what things are as well as what they are not, if we are to help them avoid arising at incorrect assumptions, conclusions, thought processes and generalization. Nevertheless, [6] asserted that by focusing on how and what learners need to assimilate instead of what we need to teach has implications for the design of learning environments and the nature of instructional practices.

As stipulated, the fundamental principle of remediation is equality of opportunity and one definitive manner in which this can be demonstrated is equality of outcomes and we have comparatively little dependable information about whether remediation is accomplishing the purpose for which it is intended, however majority of remedial math students do not remediate successfully, and the outcomes of these students are not favourable [7]. Although critics of remediation might continue to argue that this ‘‘second chance’’ is a ‘‘waste’’ of resources [8], following from these critiques, some have argued for a major restructuring of remediation or even the elimination of remedial programs altogether but they may not argue that remedial math programs are failing to meet their objective for students who remediate successfully [7]. These aspects of remedial education present a needed research agenda [9] to elaborate the obstacles that are hindering successful remediation for so many because when mathematics remediation works, it works extremely well [7].

Nevertheless, as conventional assessments are limited in their utility for assessing knowledge, cognitive processes, and learning results in authentic and complex learning and problem-solving environments [10] and only by following diagnosis, a remedial plan can either capitalize on the learner’s strengths or strengthen the areas of weakness [11]. This way, they can catch potential mistakes of confusions before they lead to problematic errors and one way to help children to self-monitor is to put them in situations that will lead to cognitive conflicts [12]. In such environments, diagnostic information about the components of a student’s knowledge and skill is important to provide appropriate feedback and tracking of learning, both of which are needed to make learning efficient and effective [10].

A diagnostic assessment aims to dynamically observe a student's performance and semantic products to make inferences about mastery of knowledge and skills in a problem-solving process [10] and such in sights into children's epistemological actions is essential for the teacher attempting to implement mathematics education reform [13]. Furthermore, diagnosis is an integral part of instructional decision-making and as the bridge between identification of students who may be at-risk for failure and delivery of carefully designed supplemental interventions, diagnosis provides valuable information about students' persistent misconceptions in the targeted domain. In conjunction, a diagnostic assessment was needed to be carried out in order to identify the specific remediation area of each students as the will vary among students [14].

With that, a study conducted by [3], identified 24 questions (Table 1) suitable to be used as diagnostic assessment in identifying misconception of students in solving negative numbers subtraction operation sentence questions involving single and double digit integers only, which revealed as an instrument that was able to discover the misconception students emulate unconsciously. Such assessments are needed to help students learn and succeed in school which can make as clear as possible the nature of their accomplishments and the progress of their learning [6], in this case students misconceptions in negative numbers subtraction operation. Moreover, [15] continuity study revealed that those misconceptions were able to be visualized into four different categories mentioned in methodology section. As a result, conventionally, the diagnostic assessment administered manually based on the following four steps:

i. Step 1: A single printed material consist of diagnostic assessment questions will be given to students.
ii. Step 2: Students will answer the diagnostic questions randomly as they wish and able to change their answers as many times as they want to.
iii. Step 3: Teacher will analyse and decide the misconception of each student with respect to its categories (A, B, C, D).
iv. Step 4: Inform the students the types of misconceptions in which remediation are needed.

Nevertheless, according to five mathematics teachers from secondary schools from a district in Malaysia, conventionally to implement such diagnostic assessment in school setting is possible but the time and work load to analyse and make visual the misconceptions information would be impossible. It was found that the process of identifying and categorizing the result into its respective categories (step 3 and step 4) would be tedious and time consuming as the sample size increases. In such it may cause many educators to avoid using diagnostic tests to guide instructional decisions because of the time involved in administering, interpreting, and implementing changes based on these approaches [16]. Thus, a computerized diagnostic assessment for Negative Numbers subtraction operation remedial process was developed and this paper is about sharing that finding.

II. RELATED WORKS

The study conducted by [17] on diagnostic learning activities includes a discussion about a method of implementing the computer algebra system *Derive* for diagnosis and remediation of basic difficulties in mathematics. Learning activities for junior high school students were developed, each activity directed at a different area of difficulty. The basic pedagogical strategy implemented in these activities is replicating and completing examples. Using partly solved examples and replication of tasks on *Derive* enables students to predict missing elements in a problem, even if they have not mastered the relevant mathematics. In this way they learn not just through trial and error, but by understanding how one part of an algebraic expression relates to the whole. Experiments with students and teachers indicate that the developed activities provide the teacher with a diagnostic tool for interacting with the student.

Meanwhile, the study by [18] focused on the effects of the CAI system constructed using cognitive conflict of decimal numbers for the sixth graders. The research took a Quasi-experimental approach using pre-test, post-test and non equivalent-group design. The pre-test, post-test and postponed-test were conducted on two groups of students to understand the effects of the system. Students were also interviewed in order to further understand the change of their concepts. This study found that although most of the sixth graders don't understand the basic concepts of decimal numbers very well and their misconceptions are similar to those found by other studies, the result of the experiments showed obvious improvement after the pre-test, post-test and postponed-test using the computer-aided learning system. The learning system helped students to obtain a "retaining effect" of decimal concepts.

According to [10], development of web-based learning (WBL) tools, courses and programs, interactive environments are increasingly prevalent in and even dominating higher education. This type of delivery poses a challenge to traditional assessment. Knowledge acquisition and skill development in a WBL environment demand alternative assessment strategies and techniques to provide information in cognitive explanations about mastery of knowledge and skill. Their study explores diagnostic cognitive assessment using Bayesian networks (BN) and an evidence centered design. Simulated data have been used to examine the functions of these models which can be used to infer students' mastery of domain knowledge and problem-solving skills, such that evidence variables developed are linked to performance components of cognitive tasks.

Findings indicate that BNs enable assessment within WBL to: (1) provide valid and interpretable diagnostic feedback on performance, and (2) track progress in mastering complex domains of cognitive knowledge and problem-solving competency.

III. Method

This study is based on our previous findings in [3];[15] whereby the demographic information of this study was 124 respondents aged 14 years old and among them was 53 boys and 71 girls. The number of respondent achieved a grade A is 26 (20.97%), grade B 58 (46.77%) and grade C 40(32.26%) for their Primary School Evaluation Examination (UPSR) in mathematics subject. The questionnaires were divided into two sections. The first section consists of demography data to understand the respondent profile. The second section consists of 24 negative numbers subtraction operation test items and only one correct answer for each item as in Table I. Face validity was done with five Mathematics teachers from five schools from a district in Malaysia. Those teachers had an experience of teaching Negative Number topic for at least five years. The questionnaire for this research was created by [3]. A pilot test was carried out [3] with a subject of 35 school students aged 14 years old from a secondary school in Malaysia. The calculation of reliability coefficient using Kuder-Richardson formula is use for dichotomy question with right wrong answer such as the objective questions [19]. The Kuder-Richardson (KR20) reliability estimation value of this instrument is 0.919544. The reliability is calculated using the KR20 formula [20] with Microsoft Office Excel 2007. According to [20], when the test format has only one correct answer then KR20 is algebraically equivalent to Cronbach alpha. Therefore, in this case the KR20 reliability estimation value of this pilot test is equivalent to Cronbach alpha coefficient.

TABLE I
NEGATIVE NUMBER SUBTRACTION OPERATION TEST ITEMS

No	Item	No	Item
1	5 – 2 =	13	-8 – 13 =
2	-5 – 2 =	14	8 – 13 =
3	-5 – (-2) =	15	-8 – (-13) =
4	5 – (-2) =	16	8 – (-13) =
5	-2 – 5 =	17	16 – 23 =
6	2 – 5 =	18	-16 – 23 =
7	-2 – (-5) =	19	-16 – (-23) =
8	2 – (-5) =	20	16 – (-23) =
9	13 – 8 =	21	-23 – 16 =
10	-13 – 8 =	22	23 – 16 =
11	-13 – (-8) =	23	-23 – (-16) =
12	13 – (-8) =	24	23 – (-16) =

According to Ager, as a platform, perhaps teachers need to look at what to teach and how technology can most effectively and interestingly be delivered [21]. Moreover, [22] added that the extensive development of new technologies has marked influence on education by facilitating the design of new learning and teaching material that can improve the attitude of learners towards mathematics and the plausibility of advanced interactive personalised learning process. Nevertheless, the important thing is that each strategy addresses a specific learning or teaching need and in general the most effective approach is one of solving instructional problems, that is, technology should be viewed as one means of some of the problems which teachers face in their teaching and which learners face in their learning and that integration can occur on a small scale, in a fairly modest fashion or it can occupy a very large and complex position in an instructional unit [23]. In relation, the function of computer integration in this study is primarily to help enhance teaching and learning remedial process in Negative Numbers subtraction operation by determining where and how it can help to enhance the exiting conditions. Thus, the diagnostic assessment was computerized based on the following principles:

i. Create a single frame which consists of all the diagnostic questions.
ii. Students can answer the diagnostic questions randomly as they wish and able to change their answers as many time as they want to.
iii. Computer system will analyse and decide the misconception of each student with respect to its categories (A, B, C, D) whereby Type A category – Subtraction Operation Involving Two Positive Integers, Type B category – Subtraction Operation Involving Negative with Positive Integers, Type C category – Subtraction Operation Involving Negative with Negative Integers and Type D category – Subtraction Operation Involving Positive with Negative Integers.
iv. Computer System will inform the students the types of misconceptions in which remediation are needed and with such information given to teachers would be of great help to proceed for remedial activities for each remedial student as they might vary.

IV. Findings

The finding of this study is to develop a computerized diagnostics assessment that is based on the four principles remarked above. In fig. 1, the *Home* button is used to return to the systems' main menu. Then, student will begin to answer all the questions displayed randomly as they wish without and sequence. After the student is satisfied with the answer he or she gave, the *Submit* button is clicked and the system will analyse to provide a report as in fig. 2. In fig. 2, at the bottom of the screen, a report is given for further action by the student. The student will be given some advises on which type of question he or she need to carry out and the next step. For example the student who answered as in fig. 2 needs remedial for sentence question type A, B and D. As you can see on the right side is a report about the types of questions answered correctly is displayed. For this example as in fig. 2, we can see that that student answered correctly 3 questions of type A, 6 questions of type c and none of questions type B and D. Meanwhile, the *Reset* button is used to redo the diagnostics assessment and student can do it as many time as they want to.

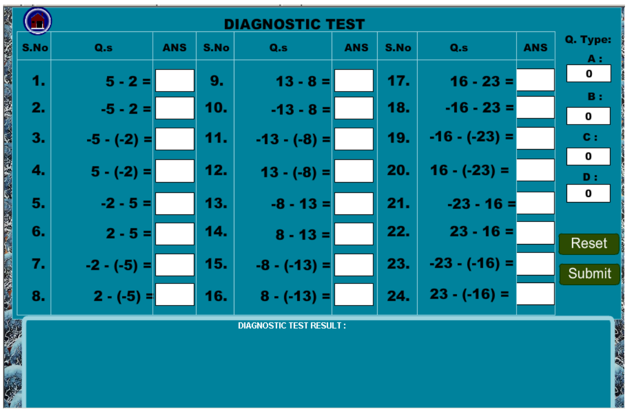

Fig. 1 Diagnostic Assessment System

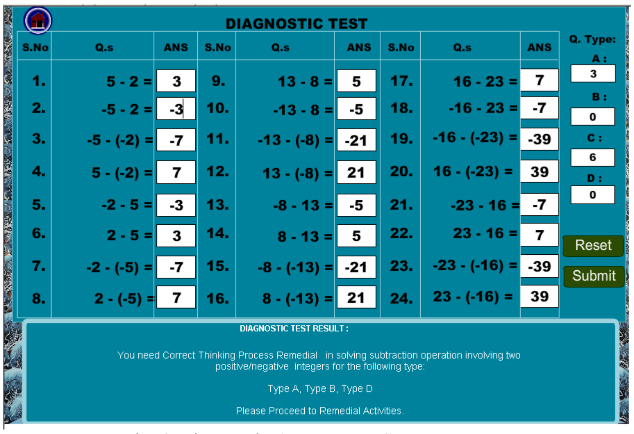

Fig. 2 Diagnostic Assessment System Report

V. Discussion

As significant investments in educational technology continue, the need to ask ourselves whether or not technology use in the classroom directly benefits student learning and added that it cannot be assumed that once educational technology tools are available, teachers will integrate them into their daily classroom instruction, then suggested that on the contrary, teachers need to go beyond the common task of just providing more machines in the classroom [24]. Furthermore, computers and computer programs are being used with increased frequency in classrooms [25] and with the rapid advancement and accessibility of technology have opened up literally worlds of possibilities for mathematics education [26]. With this increased use, comes the challenge to provide young children with developmentally appropriate programs that meet their unique needs [27].

Moreover, “The No Child Left Behind Act” [28] emphasized the importance of leveraging the power of technology in all areas of K-12 education and for these goals to be attained, it is imperative that mathematics teachers possess the knowledge and skills to determine when and how their students can use these tools appropriately and effectively. In addition, children’s learning should be supported by thoughtfully and continually assessing their mathematical knowledge, skills, and employed strategies and identifying learners’ strengths and needs, and adjusting instruction based on that information, is critical to helping children build mathematical competence and confidence [27] and innovation in mathematics education can be substantially enhanced through technology and use computer for enhancing feedback [13]. While [12] says that in all activities, including learning, mistakes can cause trouble and one way to minimize mistakes is for people to monitor their thinking and activity.

In conjunction, [14] pointed to cognitive diagnostic assessments as an emerging solution for providing detailed and precise information about students’ thinking that is needed to provide appropriate educational opportunities for students struggling in mathematics. Moreover, educators and different actors from the educational system share a similar perspective on the goals for learning and teaching for the 21st century [6] that is learners need to “*develop their abilities to think, solve problems, and become independent learners*” [29].

In such, this computerized diagnostic assessment enable students to analyse their own ability in subject domain at anytime and anyplace. It also provides immediate analysis result which would save time and work load of remediation process and most unique aspect would be that it can be repeated as many times as each students wants to without have to be worried about anything such as teachers presents. With that, remedial students will be more responsible in monitoring their own misconception based on the analysis result obtained from the computerized diagnostic assessment.

VI. Conclusions

This paper will help lay the foundation for a significant leap forward in the field of computerization of mathematics remedial education. As recognized by Clements that innovation in mathematics education can be substantially enhanced through technology and use computer for providing environments for "doing mathematics" [13]. Furthermore, according to [14], identifying bugs, i.e., persistent errors in student thinking, is the primary interest of diagnostic assessment. Thus, this critical analysis attempts to inform designers of mathematics remedial software by examining the critical attributes of mathematical diagnostic assessment intended for use by that specific population. Now, in such diagnostic assessment system, remedial students will be responsible for their own remedial process.

VII. Future Works

The usefulness of such remedial software that promotes learning will be a challenging aspect and how remedial student construct their knowledge through a process of learning by doing and reflecting with the software in adapting the knowledge in subject domain [30]. Thus, how well such system can be adapted by teachers and students in their remediation process in subject domain will be an interesting aspect to study.

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