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CALCULATOR INTRODUCTION MATHEMATICS LESSON APPRAISAL: WHAT CAN TEACHERS LEARN?

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ABSTRACT

This study presents lessons drawn from a lesson which introduced calculators for instruction to a mathematics class. It is a direct response to the call by academics for such demonstrations of how calculators can be used in mathematics classes. The study contributes teacher learning material on calculator use for their professional development.The study is guided by qualitative case study research design utilising socio-cultural activity theory. Data were collected from the teacher's scheme of work, observation of three 20 minutes lessons separated by 15 minutes breaks and lesson evaluation discussions from the lesson's video by 27 mathematics teachers in five groups. The study found that: the teacher had a high pedagogical technology knowledge level (being proficient user of a calculator, understanding principles and techniques required to use the calculator to teach mathematics). The teacher prepared thoroughly for the lesson. The class environment was conducive (allowed learners to talk to each other or stand to consult a friend on the other desk). The resources, calculator for every child were there. A minimum of two children per calculator of the same model can also do. Demonstration charts were clear and visible from the back of the class. The teacher was enthusiastic, able to sequence content and reflect on investigative teaching methods. Teacher applied demonstration, directive, individual and group work in the same lesson. Calculator application procedure notes on learners' cell phones brought the teacher on the child's side for a one-on-one tutorial. These lessons show that, calculators are not magic boxes they make mathematics exploration, experimentation and enhancement of learning mathematics patterns possible and interesting. Learners connected pen-pencil, their cell phones and the calculators in their lesson. Collaborative inquiry was the framework of the lesson. Learners were motivated to learn in and out of the class.Some of the adult learners had challenges of low vision. They took time to identify[x2], [x3] and [yx]keys. Those with thick fingers and ladies with long artificial finger nails pressed more than one key at a time. These experiences form assumed knowledge content next lesson introduction.

Key Words: Calculators, mathematics lesson, adult learners.

1. INTRODUCTION

1.1 Contextual Analysis

Introducing calculators to novice learners require an understanding of the learner, mathematics as a subject, mathematics teaching methods and knowledge of the calculator as an instructional

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tool. Consider that, the entry requirement for undergraduate degree programs differ from one university to another and program to program. In Zimbabwe, a University of Technology would not demand a very good pass in mathematics at O-level for a student majoring in Creative Art and Design. Some of them would have dropped mathematics before they wrote the O-level examinations. The dropping is a direct admission of failing before attempting. The majority of such students are not keen and have low level interest in mathematics as a subject. They are adults who need interesting approaches to introduce them to their Introduction to statistics which is a compulsory course for their degree qualification. Because of the involvement of figures in the course, a scientific calculator is an indispensable tool. It is the duty of their teacher to introduce these learners to the calculator. Some of them will be seeing the calculator for the first time, let alone using it.

The learner

The researcher's experiences as a tutor for Introduction to Statistics for undergraduate students confirmed Salih's (2003) observation that adult learners are not big children. Therefore pedagogical skills (teaching and learning of children) are not accurate substitutes for andragogy (facilitating adult learners' learning). There is need to understand adult learners' characteristics and their learning behaviours as a basis for calculator contextualised instruction in mathematics.

Knowle's (1984) andragogy model provides a comfortable springboard. It is has four assumptions which guide teachers as shown below:

a) Adult learners bring in valuable theories and concepts of mathematics and mathematics learning experiences from their previous encounters with the subject, instructional tools and its teachers. This assumption calls for pre-testing to determine the mathematics knowledge, attitude and level of interest and what the learner knows about calculators. What they can do, how they it and why,is a critical base for instruction.
b) Adults need to know the purpose of their learning before they invest effort, time and their resources as the scientific calculator. There is no harm for the teacher to spell out the course and lesson objectives before the lesson. The strategy provides targets for each student's self-evaluation and motivation.
c) Adults are used to making decisions in their everyday lives, hence expect self-direction over the nature, content and approach to their learning. Teacher can provide course with options and vary teaching approaches.
d) Adults learn more effectively when dealing with tasks and problems that they consider as real, related to and arising from the demands of their everyday lives. This calls for the teacher to free him/herself from the confines of textbook problem examples with foreign content to local examples.

From Rogers (2002: 15) we derive four adult learner categories; activists, observers, theorists and experimentalists. Each group has specific implications for mathematics education as shown in the table below:

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Table 1, Rogers (2002: 15) **Adult learner, Learning Characteristics**

Group	Characteristic and Instructional implications
Activists	Learn by involvement. Teacher can include varied calculator activities. In statistics, they can collect data in a project say height and arm's length for a group correlation project.
Observers	These prefer to wait and watch what is going on before they decide to engage themselves. Teachers can target them for group reports and exercise evaluations. They need a friend to lean on for calculator exercise. Use of procedural notes is important for them.
Theorists	Such learners want to generalise from their experiences and apply what they learn from one arena to the other. Teacher can make them lead groups in real life problem solving tasks. They can be probed to establish number patterns for calculator tasks.
Experimentalists	Enjoy devising new approaches and try to see what happens. Focus them on tasks which require different techniques.

Critical for this study is the implication that, a group of undergraduate students can be composed of students at different points of the spectrum. Chinamasa and Munetsi (2012)concluded that, there are students who want to be taught everything, those who can be guided and those who want to find everything for themselves in one class.

Bell and Gilbert (1996) cited in frank (2009, 47) classified adult learners' learning strategies into three; surface, deep and strategic levels. Critical for this study is their learning strategies in table 2, below. It presents the two extremes with the hope that, teachers can strike a balance for the group in between them.

Table 2, Adult learners' learning strategies

Learner Characteristic	Main concerns	Learning strategies
Surface level student has limited mathematics background and may have no statistics or calculator use knowledge	Complete the course with at least (50%) pass	-serious about writing notes and photocopying hand-outs for procedural knowledge -memorisation of fragmented facts -attends lectures and pays attention to all course content -aims to get the correct answer -buys a calculator for statistics -assimilates unaltered chunks of course material verbatim for regurgitation in the exam -uncomfortable with unfamiliar contexts
Strategic level student has knowledge of calculators and their use in statistics	Establish content for specific tests, evaluation and synthesis	-applies surface level approaches in a flexible combination contingent with perceived nature of task -solves one problem with more than one

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		approach and evaluates solutions -can apply the calculator as a computation and accuracy evaluation tool

One can deduce that, the students' mathematics background determines the learning strategy. When teachers manage to plan and structure their instructional methods such that there is continuity, then learning is facilitated. On the other hand, if teaching of new mathematics is at variance with students' expectations then accommodating new concepts will be effected. The good thing is that in Zimbabwe, teachers and students have positive dispositions to the use of calculators in mathematics (Nyaumwe, 2006).

The Nature of Mathematics and Motivation

A teacher's perceptions of the nature and role of mathematics influence the teacher's mathematics instructional methods. According to Dossey (1992), there is a rich mosaic of conceptions of the nature of mathematics. Those with a flair for pure mathematics consider it a static field with known set of concepts. Such teachers emphasise textbook examples, lecture methods and recall of proofs. They have problems with the integration of technology because their source of pedagogical mathematics knowledge does not accommodate it.

Experimentalists are interested in applied mathematics. They believe that mathematics is a dynamic discipline changing as a result of discoveries from experiments and applications. It relies on both logic and creativity pursued for practical purposes and its' intrinsic value. Teachers who subscribe to this school free themselves from textbook examples, structure their own examples and problems. They are not afraid of trying out new teaching methods and technology. In fact they can investigate innovative methods for including calculators in the teaching of mathematics. It is this study's purpose to show how calculators can be introduced to the teaching of mathematics.

People find it difficult to separate the need for an answer and mathematics when mathematics is a unique subject in that problems have solutions with exact answers (Boley in Chinamasa 2012, p145). Actually, the answer that one gets in mathematics is either wrong or right. Being assisted by the calculator to get the correct or exact answer motivates the student. Atherton (2003) proposed that, motivation is the most important aspect of a successful student's memory in mathematics.

According to Kyriacou (2001, p 60) motivation towards learning mathematics is a key determinant for the student's performance. It is also a source of their different attitudes to mathematics. Motivation to do mathematics can be from the mathematics subject itself. This is intrinsic motivation which can be developed by proper sequencing of the content. The desire for a good pass in mathematics is external motivation. It may be missing in students whose major area is Creative Art and Design. Teachers need to apply calculators creatively as instructional tools to improve learner performance.

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Posamentier (2013) suggested three groups of mathematics student motivation sources driven by the desire to; understand the mathematics content concepts (task or subject related), outperform others (ego-related), impress and belong to a group of able (social-related). To promote any or all of the following needs, a teacher can apply one or all of these strategies for motivating students in mathematics.

a) Identify the student's knowledge gap. A need for the subject content. This can be a simple task which calls for the content. For example, before introducing Cramer's rule for solving simultaneous equations, a teacher can ask learners to solve: $3x + 5y = 14$ and $2x + 2y = 8$ in four different ways which exclude graphical method. Students at O-level can identify and solve these equations by elimination, substitution, matrix inverse and now the fourth becomes the knowledge gap that motivates the student to want to learn Cramer's rule.
b) Present the mathematics subject content in a logical sequence of difficulty so that learners can establish the concept hierarchy incremental demand as challenging steps up the achievement ladder.
c) Guide the students to discover a pattern. It gives them an enlightening experience with a lasting effect. Posamentier (2013) suggests finding the sum of the first 100 numbers.
d) Present a challenge within reach of learners' ability. It must not be too difficult to detract them from the content of the day. When learners are challenged intellectually, they react with enthusiasm.
e) Suggest the utility value of the topic content by introducing a practical application problem. It should be brief and not complicated to motivate them.
f) Use recreational mathematics puzzles and games. They promote both the ego, social and task related motivation. Calculators can be very hand for this.
g) Get learners to be actively involved in their learning by allowing them to explore answers to satisfy their mathematical curiosity. This study shows how calculators can be introduced and used to maintain learners'interest.

Niess (2006, 200) supports the application of calculator in mathematics for the following reasons: a) calculators are motivating tools for those learners with computational limitations. (b) they are good at developing number senses in children. (c) they establish mathematical number patterns and relations. (d) they are a direct response to national standards. (e) technological knowledge and skills enhance mathematics application. (f) calculators improved students' interest, performance and confidents in mathematics. These merits associated with calculator application can only be realised if teachers have ideas of how they can introduce and use them in their mathematics lessons.

Statement of the Research Problem

There are limited mathematics teachers' resources showing them how they can apply a calculator for mathematics instruction. In Zimbabwe, the O-level mathematics syllabus 4028/2 allows scientific calculators to be used in mathematics classes and examinations. Currently (2020) mathematics learning and teaching is syllabus and text-book driven. It is teacher-centred consisting of transmission of mathematics concepts and procedures from teacher to student through a note book. Awkwardly the text-books in use do not talk about calculators, let alone how they are used. Teachers college curriculum overshadowed the use of the calculator. Nyaumwe (2006) found that teachers have a positive disposition for the calculator version but were not prepared for the new technology. In another study, Amanyi and Sigme (2016) concluded that, teachers have positive perceptions towards use of calculators for mathematics instruction, hence can integrate them in mathematics teaching and learning.Ouko (2004, p 23) observes that, teaching innovative practices like use of calculator, always places the teacher in some new role which require staff development support. Regrettably, a few mathematics teachers were trained in the use of graphic calculators. These are more expensive and rare in schools. ZIMSEC disallowed them rendering those teachers' skills to use graphic calculators obsolete. The absence of scientific calculator knowledge leaves teachers and learners unable to read and apply calculator manuals. They resort to the use of trial and error and trial and success. It is this study's purpose then, to contribute the how a calculator can be introduced in mathematics for instruction.

Research Questions

The study answers the following pertinent questions:

a) How does a lesson plan for a lesson including calculators look like?
b) What are teachers' appraisal comments for observations of a lesson which introduces calculators in the mathematics class?

Research Objectives

The study intents to:

a) Present an example of a lesson plan for introducing calculators in mathematics.
b) Establish teachers' appraisal comments for a lesson introducing calculators.

Significance of the Study

This paper demands recognition for the following contributions: it contributes knowledge of how calculators can be introduced in a mathematics class. This is a needy area which helps teachers integrate technology in the classroom. The study improves the teacher's teaching methods and confidence in the use of calculators in mathematics lessons. It provokes lectures in teachers' colleges to write similar modules for their pre-service teachers.Finally, the study contributes part of a national mathematics resources shortage solution.

2. METHODOLOGY

Research design

The study was guided by a qualitative case study research design utilising socio-cultural activity theory. According to FitzSimons (2008), in socio-cultural activity approaches, the unity of analysis is the activity itself(lesson observation and evaluation discussion), undertaken by a group of people (mathematics teachers) in order to satisfy a motive (learn how to introduce a

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calculator in a mathematics class). Various actions are undertaken to achieve a range of goals supporting the activity. The study is qualitative in that, the researcher is key instrument for data collection (White, 2005). The lesson is studied analysed and reported as a whole to project the whole picture. Data is collected in the natural teaching environment without disturbing anything in the system. Participants' actions depend on unconscious operations or skills.

It is a social case bounded within a class and focused on activities revealing how the calculators can be introduced. Bryman (2001) requires a case study researcher to explore a single entity (the case) bound by time and activity (calculator lesson) and collects detailed information by using a variety of data collection procedures. This facilitates method triangulation which is critical for the validity of qualitative data.

Population and Sampling

The population of this study is composed of human and material sources. Since the purpose of the study is to understand and not generalise findings, White (2005) said a single case is adequate. In qualitative research sample size is not an issue. Data is collected until the researcher is satisfied of having reached a variable saturation point. For this study, apurposive sample of one lesson taught in three sessions was adequate. A census of twenty- seven (27) mathematics teachers who attended the workshop evaluated the lesson from a video to deduce lessons for other teachers.

One teacher taught three 20 minutes lessons separated by two 15 minutes breaks for this study. Twenty- five (25) students participated as learners in the mathematics class. These were registered for Creative Art and Design degree at a University of Technology. The inclusion criterion for these purposive samples was being a rich source, available and willing to participate. A real class of students improved the reliability and ecological validity of the findings. According to Nyawaranda(2013) reality is a critical aspect of qualitative studies.

Instruments and Materials

Instruments used for the collection of this study's data include, a document analysis and observation guides. Document analysis guide focused us on the scheme of work for the lesson. It required us to identify the lesson's objectives, activities, calculator introduction and use. Observation guide directed our attention to classroom set up, teacher utterances, teacher- student and student-student interactions. Observation guide also required us to not when other teaching aids were introduced and used, their visibility and effectiveness. These instruments were structured by researchers for this study.

Calculators and audio-video recorders were the materials required for the study. These were provided by the institution for this study. They all had SHARP (EL-531WH) D.A.L. model. The teacher recommended this model because it is programed to use Direct Algebraic Logic. Instructing it follows the logical operations of mathematics.

Data Collection

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Data collection started by seeking permission from the institution, teacher and ministry of education which hosted the mathematics teachers' workshop under Better Schools Program (BSPZ). Two video camera photographers were hired. The next stage involved lesson observations. These were video-taped with the permission of the teacher.

Observations are used when participants (teacher and learners) are too involved to be able to objectively describe their activities (interactions and engagements with learning materials). More important is that, observations are proper when the variable indicator is action. Observation descriptions must be factual, accurate and thorough. Leedy and Ormrod (2001)suggest that, the purpose of observational data is to describe the; setting, activities, participants and their participation. Hence lesson observation was the appropriate data collection method.

Interviews were also done with the teacher and student during tea-break and after the lesson. The main purpose was to capture clarifications of teacher actions and why such an act or utterance. Learners provided instant feedback on their lesson. It mainly covered what they enjoyed and challenges that they experienced with calculators.

Photographs of some of the scenes were taken to bridge the limitations of descriptive language. A camera captures authentic images which portray the reality of that moment for later analysis. White (2005, p164) describes the use of photographs as a way of capturing those aspects of life which cannot be described by way of words.

After a week the video was run three times at a Better Schools Program for mathematics teachers' technology orientation workshop. The teachers were divided into five groups of at least five teachers each for Focus Group Discussions. Each group was asked to evaluate the lessons and suggest lessons for other teachers from the videos.

Data Analysis and Presentation

Data analysis for qualitative studies can be done simultaneously with data collection. For example, researchers recorded common points raised by focus groups while they were presenting for a group report. Students' views were captured during tea-break. The overall data analysis was carried out the following sequence; reading through all the notes, classifying findings according to research questions, arranging the findings and describing.

Presentation was defined by the nature of the variable. Mathematics teacher experience is a quantitative continuous variable. It is presented on a frequency density graph. The lesson plan was considered as the teacher's road map of what students need to learn and *how* they learn it. The *how* part shows step-by step methods for introducing calculators. To reduce distortions, the lesson plan was typed and presented as it was.Comments are transcribed verbatim to allow readers to deduce more from the semantics used. Lessons deduced are summarised in tables.

Photograph presented what actually transpired. It is presented particularly for readers to deduce more information about the learners' engagement in learning with calculators.

3. STUDY FINDINGS AND DISCUSSIONS

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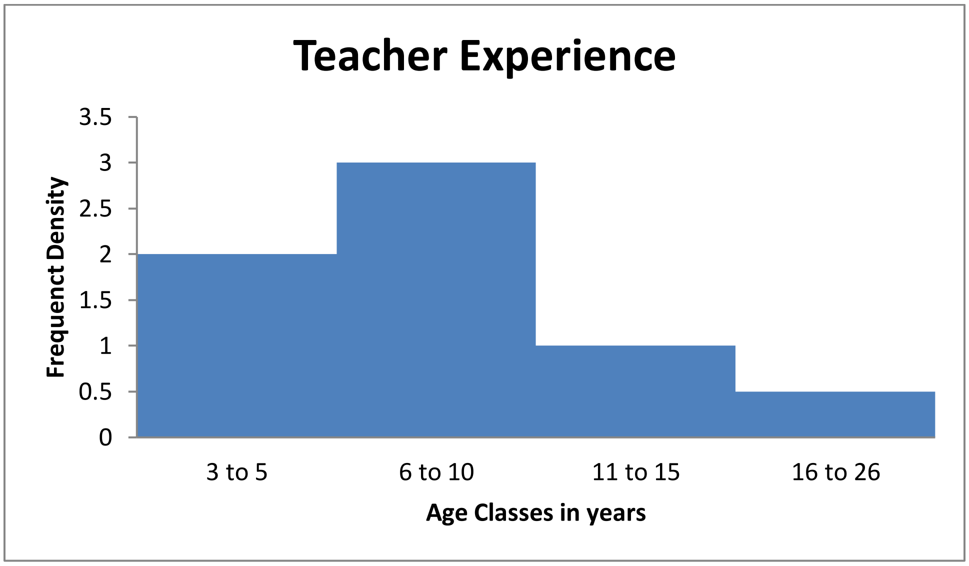
Figure 1, Teacher distribution by Teaching Experience N = 29



The graph shows that, the majority of participants (including researchers) have mathematics teaching experience ranging between (6 to 10) years. These teachers are conversant with mathematics lesson observations. Their evaluations are valid. Another aspect to note is the experience distribution's positive skewedness. This could be accounted for by the migration of mathematics teachers to neighbouring countries for greener pastures and expert export. Mathematics teachers' participation in this workshop is part of the knowledge sharing to improve technology implementation and quality of mathematics teaching and learning.

Lesson Plan

Topic: Calculator Introduction

Lesson Objectives

By the end of the lesson, learners should be able to:

a) Use calculators informally for addition of whole numbers up to 15 (Magic Square)
b) Establish number patterns for squared whole numbers ending with 5, ($15^2 = 225$)
c) Apply calculators to square numbers using direct keys [x^2],
d) Identify a calculator key for a general rule for raising any number to any power [y^x]

Materials: Projector, 28 calculators, paper and pencils, cell phones, chart showing calculator keys to be used

Lesson Conception activity	Activity's Objectives	Teacher –Learner activities	Lesson Core points and Teaching hints
Lesson 1 Magic Square adding	-add 3 whole numbers from 1 to 9	-Teacher presents task (Magic Square)	Task: *Given natural numbers 1 to 9, fit them in*

to 15	to a sum of 15 -use mental abilities cell-phones, calculators -establish pattern	-Learners draw squares on paper and create the magic square -Checking of answer individually by peer or teacher (collaboration) -learners establish pattern -learner presents correct answer to class -Teacher project the correct solution and illustrate the pattern	*the magic square so that any three squares added in a straight line add up to 15.* -learners use familiar instruments informally -explore calculator keys and their output -individual, peer and teacher checking (sum 15) -pattern requires 5 at the centre square 1, 2, 3, 4, 5, 6, 7, 8, 9 1+5+9 2+5+8 *Rotation of any of* 3+5+7 *these 3 in the* 4+5+6 *9 squares* Note: 1,2,3,4, down wards And 6,7,8,9 upwards
Break	Break	Break	Break
<u>Lesson 2</u> Pattern for Square Numbers Ending by 5: 15^2, 25^2, $35^2 \ldots 95^2$	-compute the square of numbers using pen-pencil, cell-phone' calculators	-Teacher links sum of magic square 15 to squaring 15 i.e. 15^2 -challenges learners to square : 25, 35, 45, 55, 65, 75, 85, 95 and find a pattern -Learners work as individuals, pairs or groups	Task: Find a pattern for finding the answers to: 5^2, 15^2, 25^2, $35^2, \ldots \ldots 95^2$. Does the patter work for squaring all numbers, e.g. 43^2 -Teacher lead deduction of pattern in pattern column (See lesson 2, Pattern Teaching hints Appendix 1)
Break	Break	Break	Break
<u>Lesson 3</u> Calculator Introduction	-identify numeric keys (1,2,….9) -Identify functional keys [y^x] [x^2] and [x^3] on calculators -use functional keys for computations of 45^2, 65^2, 15^3, 25^3, 35^4, 45^6	-teacher projects image in board -ask learners to identify numeric keys, function keys and what they do -allows learners time to explore and exhaust curiosity -Teacher focus	Teacher to demonstrate 15^2 by a) 15 <u>x 15</u> 1 5 0 <u>+ 75</u> <u>22 5</u> b)15^2= (1+1)x1 =2 25 c)[1][5][x^2] = 225 d)[1][5][x^3] = 3375

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		students on [y^x] [x^2] and [x^3] keys and uses them for 15^2, 15^3, 15^4, 15^5n -learners write notes on their cell phones	e) [1][5][y^x][3]= 3375 f) [1][5][y^x][4] = 50625 g) [1][5][y^x][5] = 759 375

Lesson Appraisal

The following lesson appraisal comments were collected from students and teachers who observed the lesson live and from videos:

1.Weaknesses

a) Cell phones detract students when used in class. A student can concentrate on something else instead of its use in the subject.
b) The 20 minutes given to each lesson was a bit less, some students could not cope.
c) Use of appropriate language and symbols such as Sum (Σ) can improve the learning.
d) Some of the adult learners had challenges of low vision. They took time to identify[x^2], [x^3] and [y^x] keys**.** Those with thick fingers and ladies with long artificial finger nails pressed more than one key at a time.
e) Planning such lessons is time consuming for mathematics teachers because of large classes, heavy teaching loads and marking daily.

2.Lesson's Strengths

a) There was student involvement from start to end. Use of calculators promotes child-centred learning and persistence in mathematical tasks.
b) Students continued learning outside the class showing that they were motivated

Learners discuss calculator use out of the class

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Photo by researcher in the field

c) The three lessons'content dove-tailed into each other, with lesson 3 concluding with the formal application of calculators. Learners formalised computations which they were doing informally.
d) Content was well organised with difficulties increasing from one level to another, see lesson 3 notes. The flow of learning is clear. In fact the idea of using 15 throughout is creative.
e) We did learn a lot as teachers from observing this lesson. The magic square pattern and squaring of multiples of 5 were new and exciting. We used the calculators to check the accuracy of those answers. That compelled us to use calculators.
f) The teacher's notes particularly on lesson 1, revealed the pattern clearly. Several patterns can be established from lesson 2 patterns if students are given time to explore them.
g) Calculators foster growth of mind-set. Trying different strategies and getting correct answer (lesson 1) provides a sense of accomplishment and pride. Teachers should reward the trials rather than blame for incorrect answer.
h) This lesson motivated me to observe that, the numeric keys (left and right diagonals and the vertical and horizontal) add up to 15. I am wondering why the order is like that. This lesson provoked me to be observant and get more inquisitive.
i) Calculators boost learners' mathematical thinking as long as the teacher devotes sufficient time to teach them how to use them.
j) Calculators enhance exploring of number combinations without hassle.

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k) In these lessons, learners used calculators as accuracy checking tools, exploring mathematical concepts and patterns.

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Appendix 1 Lesson 2, Pattern teaching Hint

Task	Pattern Column	Answer in parts	Answer as one
5^2	(0 + 1)x 0 = 0 →	0 25	→ 25
15^2	(1+ 1) x 1 = 2 →	2 25	→ 2 25
25^2	(2 + 1) x 2 = 6 →	6 25	→ 6 25
35^2	(3 + 1) x 3 =12 →	12 25	→ 1225
45^2	(4 + 1) x 4 = 20 →	20 25	→ 2025
55^2	(5 + 1) x 5 = 30 →	30 25	→ 3025
65^2	(6 + 1) x 6 = 42 →	42 25	→ 4225
75^2	(7 + 1) x 7 = 56 →	56 25	→ 5625
85^2	(8 + 1) x 8 = 72 →	72 25	→ 7225
95^2	(9 + 1) x 9 = 90 →	90 25	→ 9025