IMPORTANCE OF DIAGNOSTIC ASSESSMENTS AS A PRECURSOR TO DIFFERENTIATED LEARNING

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Importance of Diagnostic Assessments

Assessments are essential to determine how much a child has learnt. They are required in order to provide a complete picture of learning, information on learning progress of the student, to diagnose specific strengths and weaknesses in a student's learning, and to motivate further learning. Assessment is a continuous and an ongoing process.

Diagnostic assessments help to find out the thought process of the child, his reasoning for a particular answer. They help determine the level of knowledge and skill of the child. In our cloud based Adapative Math Learning Tool called Mindspark a diagnostic test on decimal comparison has been introduced based on research by Dr. Kaye Stacey from The University of Melbourne, Australia. The test, called Decimal Comparison Test (DCT), which has been attempted by over 3000 students in 2 years, classifies students into various misconception codes based on their thinking while comparing pairs of decimals. They are taken through specific remedial paths and finally given a post -DCT to check their learning.

DCT (Decimal Comparison Test):

Students' understanding of decimal numeration is mapped using a short test called the Decimal Comparison Test (DCT), where students have to choose the larger number from each of 30 pairs of decimals. The pairs are carefully chosen so that from the patterns of responses, a student's (mis) understanding can be diagnosed as belonging to one of a number of classifications mentioned later (shown in Step 1 in Figure A)

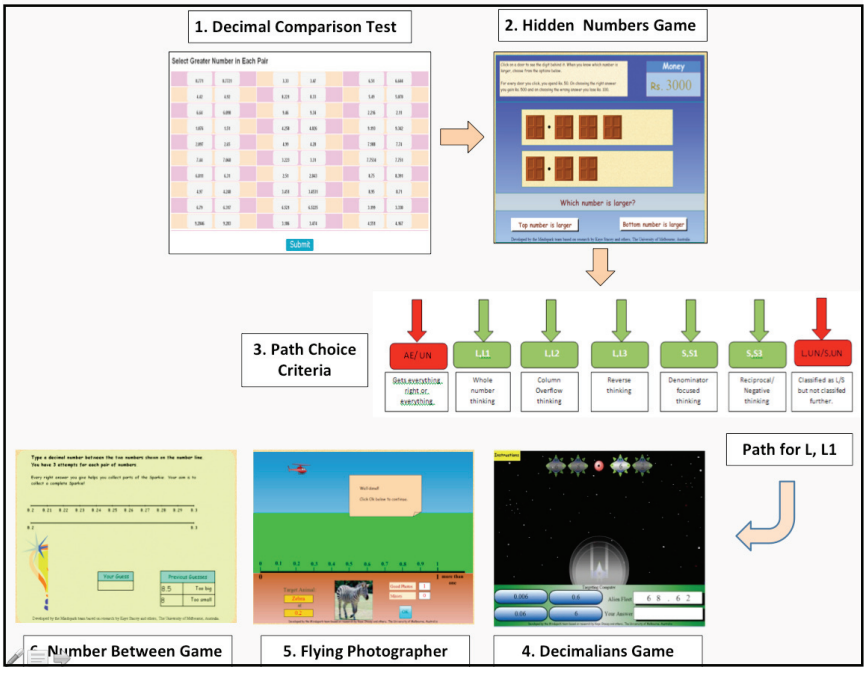


Figure A: Illustrated Flow of students in Mindspark's Decimal module

This is followed by a game called Hidden Numbers where students are presented with two decimal numbers with digits hidden behind closed doors; the task is to find which number is larger by opening as few doors as possible. Requiring similar knowledge to that required for the success on DCT, the game also highlights the place value property that the most significant digits are those to the left. (shown in Step 2 in Figure A)

The game helps us distinguish the two major ways of thinking students have- 'longer is larger' (the greater the length of the decimal,the larger its value) and 'shorter is larger' (the lesser the length of the decimal, the larger its value). Further specific questions and response of the student help us identify the logic behind their thinking.

Based on the misconception bucket the student is classified into, he/ she is presented with a specific order of questions and learning games that will help clear his/ her misconceptions.

Classification and details of the code:

PRIMARY MISCONCEPTION 'TYPE'	SECONDARY MISCONCEPTION 'TYPE'	HOW DOES THE STUDENT THINK?	SO.. WHAT'S HIS/ HER ANSWER?
'Longer- is- larger' (L)	Whole number thinking (L,L1)	Treats decimal portion as another whole number. Numerator focused thinking chooses 0.53 > 0.006 as 53 > 6, while String length thinking chooses 0.53 < 0.006 as 006 has 3 digits and 53 has two.	4.8 < 4.75 as 8 < 75
	Zero- makes- smaller thinking + Column Overflow Thinking (L,L2)	0 after a decimal point makes the number smaller. Considers 0.8 as 8 tenths and 0.75 as 75 tenths.	Correctly chooses 4.03 < 4.2 but incorrectly chooses 4.8 < 4.75 as 8 tenths < 75 tenths.
	Reverse thinking (L,L3)	Believes right most columns have largest place value, so compares from the right- most column first.	4.8 < 4.75 as 5 hundred 7 tens > 8 tens
'Shorter- is- larger' (S)	Denominator focused thinking (S,S1)	Reads a one digit decimal as a number of tenths, a two digit decimal as a number of hundredths and then incorrectly generalises the fact that 1 tenth is greater than 1 hundredth to 'any number in the tenths is greater than any number in the hundredths'.	4.8 > 4.75 4.6 > 4.75
	Reciprocal thinking or negative thinking (S,S3)	Treats decimal portion as something analogous to the denominator of a fraction or as a number 'on the other side of zero' or less than zero.	4.82 < 4.3 as 1/82 < 1/3 or as -82 < -3.

Different groups of decimal pairs to help classify the students **

To distinguish between the L* (fails group 1, passes group 2) and S*- type (passes group 1, fails group 2)

GROUP 1	GROUP 2
4.8/ 4.73	5.73/ 5.6

To distinguish among L,L1* (fails group 3 , passes group 4), L,L2 *(passes both group 3 and 4) and L,L3* (fails both group 3 and 4).

GROUP 3	GROUP 6
3.72/ 3.074	1.42/ 1.27

To distinguish between SS1* (fails group 4, passes group 5) and SS2* (fails both group 4 and 5).

GROUP 4	GROUP 5
8.512/ 8.51	1.4/1.2

**Refer to appendix for details on how the numbers are generated in each group

Remediation

The remediation path, once misconception codes are generated, consists of learning units on decimals concepts (which is fixed) as well as certain games (dependant on the misconception code) that help students learn the fun way and clear their misconceptions. For example, a student who has got the code L,L1 (Whole Number Thinkers) will initially get a game called Decimaliens which is a classic shooting game designed to link various representations of the value of digits in a decimal number. For example, the 4 in the number 3.46 is to be identified as representing 4 tenths, 0.4, 4/10 as well as in more difficult representations requiring reunitising as 40 hundredths, 400 thousandths.

Students with whole number thinking will be helped by this game where they realize that the place value of 6 in 1.6 is 0.6 and not 6 as perceived by whole number thinkers.

This is followed by a game called Flying Photographer (after attempting a few questions on decimals) where students 'photograph' an animal by clicking when a helicopter passes a specified number on a number line. This task requires understanding of decimal numeration and relative size of decimal numbers. Whole number thinkers usually expect 0.23456 to be very large and are surprised to see it close to zero).

The next game that appears (again after working on some questions on decimals) is 'Number Between'. The game is played on a number line, where students have to type in a number between a given pair of end points. The main situation which produces errors is that many students (including whole number thinkers) are unable to insert a number between, say, 3.46 and 3.47 as they think these are consecutive numbers. In one of the student trials, 2 students were made to play the game again after they had finished and this time they were able to place a number between 3.001 and 3.002 and also explain from what they observed that 3.001 and 3.002 are the same as 3.0010 and 3.0020 respectively and hence 3.0015 would come in between. Working on more questions like this, where the system shows decimals that exist between the given 2 decimals, challenges their thinking and many students are able to look at decimals in the true light.

Once students have completed their remediation path, they have a post- DCT (30 pairs of decimals where the larger decimal should be chosen- decimals dynamically generated) to record the codes again and check improvement if any.

Movement of students from one code to the other

preDCT & postDCT

	AE	L,L1	L,L2	L,L3	L,UN	S,S1	S,S3	S,UN	UN	Pre Sum
AE	509	0	3	3	1	3	0	0	8	527
L,L1	5	3	3	0	0	0	0	0	0	11
L,L2	17	1	13	0	0	5	1	0	1	38
L,L3	2	0	0	1	0	0	1	0	0	4
L,UN	0	0	1	0	0	0	0	0	0	1
S,S1	15	1	2	0	0	0	2	2	0	22
S,S3	2	0	1	0	0	1	2	0	0	6
S,UN	1	0	0	0	0	0	0	0	0	1
UN	13	2	1	1	0	4	1	1	10	33
Post Sum	564	7	24	5	1	13	7	3	19	643

The row headers correspond to the misconception codes in pre test and column headers correspond to misconception codes in post test.

Observations:

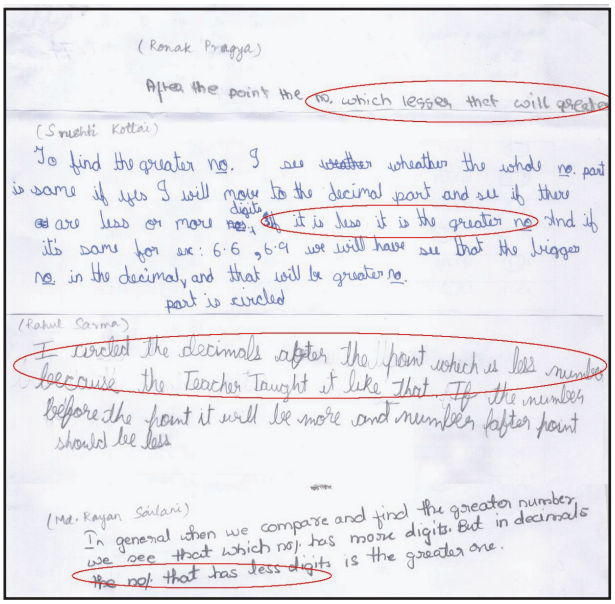
1) Roughly 80% of the students are Apparent Experts (AE) in comparison of decimals.
2) LL2 (Zero-makes smaller + Column overflow) and SS1 (Denominator Focused Thinking) seem to be the major misconceptions among students with 6% and 3% prominence respectively.
3) Out of 38 students in LL2 (pre), 13 remained in LL2 while 17 moved to AE in the post test. 6 have moved to S category.
4) Out of 22 students in SS1 (pre), 0 remained in SS1 while 15 moved to AE in the post test. 3 have moved to L category.

Student Interview Observations:

Students used various methods/ thinking to compare two decimals-

1) Given 2 decimals, see which one is closer to the next whole number or what should be added to bring it to the next whole number (Students may or may not answer correctly with this reasoning).
2) Add zeroes to make the 2 decimals of the same string length and then compare the 2.
3) Compare the whole number. If same compare the tenths, hundredths etc in that order.
4) 'Fewer digits is the greater decimal'. (Some can clearly explain this is because 'tenths is greater than hundredths')
5) After the decimal point the number which is lesser is the greater decimal. (Here they look at the value whereas in the previous case they look at the number of digits after the point).

Hand written responses of some students about how they choose the larger decimal in a given pair.



Points to consider for Version 2

1) The current format does not classify a student into 2 different misconceptions. He is either put under UN (Unclassified) category or, in case he is classified under 'L' or 'S' and there has multiple wrong understandings, is classified into 'L,UN' and 'S,UN' respectively. A provision to let students be classified into more than one misconception type should be considered.
2) Hidden Numbers can be used as a diagnostic test in the middle of the remedial path to check for student's learning and understanding after a couple of games, so that the path may be modified in case his misconception has shifted from one to the other during the course of remediation.

Appendix

$A_0.A_1A_2....Am$ is the larger decimal number

$B_0.B_1B_2....Bn$ is the smaller decimal number

GROUP	EXAMPLES	DESCRIPTION
GROUP 1 (L-S)	4.8/ 4.73 7.35/ 7.129	$A_1 > B_1 + 1$, B_2 free or $A_1 = B_1 + 1$ & $B_2 < 5$ X, Y belong to [1,9], keep m < n
GROUP 2 (L-S)	5.73/ 5.6 3.482/ 3.17	$A_1 > B_1 + 1$, or $A_1 = B_1 + 1$ & $B_2 < 5$ X belongs to [1,9], Y belongs to [1,4] keep m > n.
GROUP 3	3.72/ 3.074 5.25/ 5.046	$B_1 = 0$, $A_1 <= B_2$, X, Y belong to [1,9], keep m < n
GROUP 4	6.512/ 6.51 8.742/ 8.74	$A_1 = B_1 < 9$, $A_2 = B_2 < 9$, $A_3 < 5$, $B_3 < A_3$, keep m > n
GROUP 5	1.4/ 1.2 3.74/ 3.58	$A_1 > B_1$, X, Y belong to [1,9], keep m = n
GROUP 6	1.42/ 1.27 8.751/ 8.574	$A_1 > B_1 + 1$, $A_2 < B_2$, $A_3 < B_3$, m = n

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