Appendix

Pre-test Questionnaire

Section 1 - Convergence Task

INSTRUCTIONS: Please take no more than 10 minutes to answer the following four questions:

1. A man bought a product for $6 and sold it for $7. Then he bought the ***same*** product for $8 and sold it for $9. What is his total profit?
2. There are 10 New Zealand and 10 Australian coins of similar size and weight in a box. You take the coins out of the box without looking at them. What is the smallest number of coins you need to take out of the box to be absolutely sure that you have 5 coins of the same country, either New Zealand or Australian?
3. High in the mountains three mountaineers needed a fire to make hot drinks. They built a fire and shared it equally. The first contributed 3 pieces of wood and the second five. The third person did not have any pieces of wood so he gave $8 to the other two. How should they divide the $8 in a fair way?
4. The price of a product was raised by 10%. Later it fell by 10%. Did it become:

   a) cheaper;

   b) more expensive;

   c) the same?

Section 2 - Divergence Task

INSTRUCTIONS: The following task involves "brainstorming" -- generating as many ideas you can in a relatively short time. Please spend no more than 5 minutes.

Task: Name possible uses for a brick (as many as you can)

Section 3 - Cognitive Reflection Task

INSTRUCTIONS: Please take no more than 5 minutes to answer the following five questions:

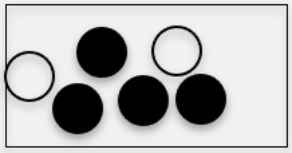
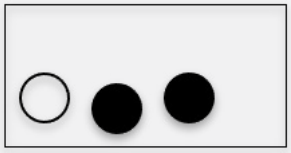
1. A bat and a ball cost $2.20 in total. The bat costs $2.00 more than the ball.

   How much does the ball cost? ____ cents
2. If it takes 8 machines 4 minutes to make 8 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size.

   If it takes 12 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ____ days
4. In the example shown below the area of the shape shown on the left is decreased by removing a unit square. If the area of shape on the left is decreased by removing unit squares will the perimeter always decrease?

   Yes ☐ No ☐

5. Two boxes, A and B, each contain black and white balls that are thoroughly mixed. Which box gives a better chance of picking a black ball at random, without looking?

	
Box A:	**Box B:**
4 black and 2 white	**2 black and 1 white**

Box A ☐ Box B ☐ Same chance ☐

Section 4 - Self-Assessment

INSTRUCTIONS: Please circle the numbers on the right below indicating your level of agreement with each statement.

5 – STRONGLY AGREE (SA)

4 – AGREE (A)

3 – NEUTRAL (N)

2 – DISAGREE (D)

1 – STRONGLY DISAGREE (SD)

		SA	A	N	D	SD
1.	Solving puzzles can enhance your creativity.	5	4	3	2	1
2.	Solving puzzles makes you a more innovative thinker.	5	4	3	2	1
3.	Being able to solve problems is a useful career skill.	5	4	3	2	1
4.	The knowledge and skills related to solving puzzles will be useful to me in the future.	5	4	3	2	1
5.	Solving puzzles motivates me to work harder at mathematics.	5	4	3	2	1
6.	Solving puzzles can be detrimental to mathematics understanding.	5	4	3	2	1
7.	I think knowing how to solve puzzles is very useful for my learning.	5	4	3	2	1
8.	I think working on puzzles is a waste of time for me.	5	4	3	2	1
9.	Even if a puzzle or problem is difficult, I can usually solve it if I try.	5	4	3	2	1
10.	I feel that I have a good mind for solving puzzles and problems.	5	4	3	2	1
11.	I'm not good at solving puzzles.	5	4	3	2	1
12.	I am very good at solving puzzles	5	4	3	2	1
13.	I am confident at solving puzzles.	5	4	3	2	1
14.	I sometimes feel anxious when solving puzzles.	5	4	3	2	1
15.	I often need more help on how to solve puzzles.	5	4	3	2	1
16.	I think solving puzzles is boring.	5	4	3	2	1
17.	I don't like working on puzzles.	5	4	3	2	1
18.	I enjoy solving puzzles.	5	4	3	2	1

Open-ended questions

Question 1. Do you think solving puzzles can enhance your problem solving skills?

a) Yes In which way? b) No Why not?

Question 2. Do you think solving puzzles can enhance your creativity?

a) Yes In which way? b) No Why not?

Question 3. Do you think solving puzzles can benefit you in the future?

a) Yes In what way? b) No Why not?

Computer Games

During a typical week, how many hours do you spend on each of the following types of computer games or activities:

	0 hours	1 to 2 hrs	3 to 5 hrs	6 to 10 hrs	>10 hrs
Massive Multiplayer Online	O	O	O	O	O
Role-Playing Games	O	O	O	O	O
Real-Time Strategy Games	O	O	O	O	O
Puzzles	O	O	O	O	O
Adventure/Action	O	O	O	O	O
Sports	O	O	O	O	O
First-Person Shooter/Combat/Stealth	O	O	O	O	O
Educational	O	O	O	O	O
Simulations	O	O	O	O	O

Section 5 – Additional Info

1. What was your grade in the course pre-requisite to this one?

C-	C	C+	B-	B	B+	A-	A	A+
O	O	O	O	O	O	O	O	O

2. What is your gender? a) Male b) Female c) Gender diverse
3. What is your age group? a) <19 y.o. b) 20-24 c) 25-29 d) 30-39 e) >40 y.o.
4. Are you a domestic student or international? a) domestic b) international
5. What is your major? a) maths b) science c) engineering d) computer science e) other (please specify)

Post-test Questionnaire

Section 1 - Convergence Task

INSTRUCTIONS: Please take no more than 10 minutes to answer the following four questions:

1. A man bought a product for $50 and sold it for $60. Then he bought the ***same*** product for $70 and sold it for $80. What is his total profit?
2. There are 60 coins of similar size and weight from different countries in a box:
   30 American, 20 Australian and 10 New Zealand. You take the coins out of the box without looking at them. What is the smallest number of the coins you need to take out of the box to be absolutely sure that you have 10 coins of the same country?
3. Three backpackers cooked rice for dinner and shared it equally. The first gave 400 g of rice and the second 200 g of rice. The third backpacker did not have any rice so he gave $6 to the other two. How should they divide the $6 between them in a fair way?
4. Which is the bigger reduction:
   a) a 30% cut;
   b) a 20% cut followed by a 10% cut;
   c) the same?

Section 2 - Divergence Task

INSTRUCTIONS: The following task involves "brainstorming" -- generating as many ideas you can in a relatively short time. Please spend no more than 5 minutes.

Task: Name possible uses for a shoe (as many as you can)

Section 3 - Cognitive Reflection Task

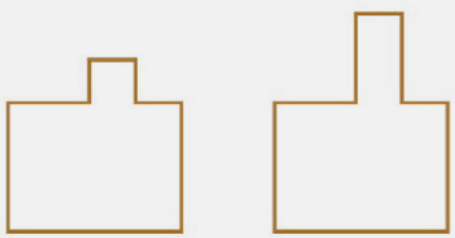
INSTRUCTIONS: Please take no more than 5 minutes to answer the following five questions:

1.A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball.
   How much does the ball cost? ____ cents

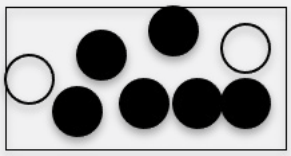
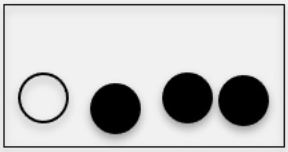
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes

3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size.
   If it takes 16 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ____ days

4. In the example below the area of the shape shown on the left is increased by adding a unit square. If the area of shape on the left is increased by adding unit squares will the perimeter always increase?
   Yes ☐ No ☐



5. Two boxes, A and B, each contain black and white balls that are thoroughly mixed. Which box gives a better chance of picking a black ball at random, without looking?

	
Box A:	**Box B:**
6 black and 2 white	**3 black and 1 white**

Box A ☐ Box B ☐ Same chance ☐

Section 4 - Self-Assessment

INSTRUCTIONS: Please circle the numbers on the right below indicating your level of agreement with each statement.

5 – STRONGLY AGREE (SA)

4 – AGREE (A)

3 – NEUTRAL (N)

2 – DISAGREE (D)

1 – STRONGLY DISAGREE (SD)

		SA	A	N	D	SD
1.	Solving puzzles can enhance your creativity.	5	4	3	2	1
2.	Solving puzzles makes you a more innovative thinker.	5	4	3	2	1
3.	Being able to solve problems is a useful career skill.	5	4	3	2	1
4.	The knowledge and skills related to solving puzzles will be useful to me in the future.	5	4	3	2	1
5.	Solving puzzles motivates me to work harder at mathematics.	5	4	3	2	1
6.	Solving puzzles can be detrimental to mathematics understanding.	5	4	3	2	1
7.	I think knowing how to solve puzzles is very useful for my learning.	5	4	3	2	1
8.	I think working on puzzles is a waste of time for me.	5	4	3	2	1
9.	Even if a puzzle or problem is difficult, I can usually solve it if I try.	5	4	3	2	1
10.	I feel that I have a good mind for solving puzzles and problems.	5	4	3	2	1
11.	I'm not good at solving puzzles.	5	4	3	2	1
12.	I am very good at solving puzzles	5	4	3	2	1
13.	I am confident at solving puzzles.	5	4	3	2	1
14.	I sometimes feel anxious when solving puzzles.	5	4	3	2	1
15.	I often need more help on how to solve puzzles.	5	4	3	2	1
16.	I think solving puzzles is boring.	5	4	3	2	1
17.	I don't like working on puzzles.	5	4	3	2	1
18.	I enjoy solving puzzles.	5	4	3	2	1

Open-ended questions

Question 1. Do you think solving puzzles can enhance your problem solving skills?

a) Yes In which way? b) No Why not?

Question 2. Do you think solving puzzles can enhance your creativity?

a) Yes In which way? b) No Why not?

Question 3. Do you think solving puzzles can benefit you in the future?

a) Yes In what way? b) No Why not?

Section 5 – Engagement

A) Approximately how many puzzles did you solve correctly over this semester?

a) less than 25% b) between 25% and 50% c) between 50% and 75% d) more than 75%

B) Approximately how many lectures did you attend this semester?

a) less than 25% b) between 25% and 50% c) between 50% and 75% d) more than 75%

To what extent has the use of puzzles in this course emphasised the mental activities listed below?
Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

1. **Memorising** facts, ideas or methods so you can repeat them in almost the same form.
2. **Analysing** the basic elements of an idea, experience or theory such as examining a specific situation in depth and considering its components.
3. **Synthesising** and organizing ideas or information into new, more complicated interpretations and relationships.
4. **Evaluating** the value of information, arguments, or methods such as examining how others gathered and interpreted data and assessing and accuracy of their conclusions.
5. **Applying** theories and/or concepts to new problems or situations.

To what extent has the use of puzzles in this course contributed to your knowledge, skills, and personal development in the following ways?

Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

6. **Acquiring job or career related** knowledge and skills
7. **Writing** clearly, accurately, and effectively
8. **Thinking** critically and/or analytically
9. **Learning effectively on your own**, so you can identify, research, and complete a given task.
10. **Working effectively with other individuals.**

Content Validation Survey

Congratulations! You have been identified as an "expert" in the area of mathematics and/or creative thinking. For that reason, you have been chosen to help validate the content of items/questions aimed at assessing three types of thinking related to solving puzzles and problems. If you're willing do so, please follow the instructions below.

INSTRUCTIONS

1. There are THREE categories of thinking. These are outlined in the table below. Please begin by familiarising yourself with each category and its definition.

Categories	Conceptual Definition
I. Intuitive Thinking	*Intuitive thinking* is fast, automatic, and largely unconscious. In puzzle- or problem-solving tasks intuitive (aka System 1) thinking can ***lead to mistakes when problems appear*** to have a ***simple, straight-forward, intuitive solution***.
II. Divergent Thinking	*Divergent thinking* tasks involve slower, more effortful and conscious thought processes (aka System 2 thinking) aimed at ***generating as many creative solutions as possible*** to a problem or situation (e.g. brainstorming).
III. Convergent Thinking	*Convergent thinking* tasks also involve System 2 thinking, but instead the aim is to ***find a single correct answer*** to a problem or situation that often requires taking a novel approach to the problem or seeing the problem from a different perspective.

2. On the next several pages, you are asked to compete two Rating Tasks:
   - Rating Task I (Content Validation), which presents you with a list of 13 items (maths puzzles and problems) and asks you to 1) select which ONE of the THREE categories described above, 2) indicate how certain you are about the choice of category, and 3) rate how relevant you think the item is to the category chosen.
   - Rating Task II (Item Equivalence), which presents you two versions of an item (original and adapted) and asks you to rate the degree to which you think they are equivalent (and, thus, could be used interchangeable as parallel forms).

When you have completed this form, please return it to me by emailing: jm.stephens@auckland.ac.nz

Thank you for your participation!

Jason

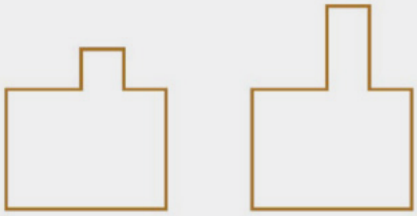
RATING TASK I – CONTENT VALIDATION

ACC in PS Questionnaire		**Category**			**Certainty**			**Relevance**		
Instructions: *For each item listed below...* *(1) Place ONE tick in the* ***Category*** *section to denote the Category in which you believe the item belongs.* *(2) Place ONE tick in the* ***Certainty*** *section for to represent how certain you feel about your choice of category.* *(3) Place ONE tick in the* ***Relevance*** *section to indicate how relevant you feel each item is to your chosen category.*		Convergent Thinking	Divergent Thinking	Intuitive Thinking	Not sure	Somewhat sure	Very sure	Low or no relevance	Somewhat relevant	Highly relevant
1	A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ____ cents									
2	Please list as many possible uses for a brick: *(textbox allowing for endless entries)*									
3	A man bought a product for $6 and sold it for $7. Then he bought the **same** product for $8 and sold it for $9. What is his total profit?									
4	If it takes 8 machines 4 minutes to make 8 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes									
5	Please list as many possible uses for a paperclip: *(textbox allowing for endless entries)*									
6	There are 10 New Zealand and 10 Australian coins of similar size and weight in a box. You take the coins out of the box without looking at them. What is the smallest number of coins you need to take out of the box to be absolutely sure that you have 5 coins of the same country, either New Zealand or Australian?									
7	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 12 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ____ days.									
8	Please list as many possible uses for a shoe: *(textbox allowing for endless entries)*									
9	High in the mountains, three mountaineers needed a fire to make hot drinks. They built a fire and shared it equally. The first contributed 3 pieces of wood and the second contributed 5 pieces. The third person did not have any pieces of wood so he gave $8 to the other two. How should they divide the $8 in a fair way?									

10	In the example shown below the area of the shape shown on the left is decreased by removing a unit square. If the area of shape on the left is decreased by removing unit squares will the perimeter always decrease? Yes ☐ No ☐ 									
11	Please list as many possible uses for a newspaper: *(textbox allowing for endless entries)*									
12	The price of a product was raised by 10%. Later it fell by 10%. Did it become: *(cheaper, more expensive, or same price)*									
13	Two boxes shown BELOW, A and B, each contain black and white balls that are thoroughly mixed. Which box gives a better chance of picking a black ball at random, without looking?									

RATING TASK II – ITEM EQUIVALENCE

Cognitive Reflection Task (Intuitive Thinking)		**Equivalence**		
Instructions: *For each pair of items (e.g., 1A and 1B), please use the three-point scale on the right to indicate their degree of* ***equivalence****. That is, the extent to which you believe the two items are equal or interchangeable in requiring the same type and level of creativity thinking and/or problem-solving skill to solve.*		**Low**	**Moderate**	**High**
1A	A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ____ cents			
1B	A bat and a ball cost $2.20 in total. The bat costs $2.00 more than the ball. How much does the ball cost? ____ cents			
	**If not "High", please suggest how to improve:*			
2A	If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes			
2B	If it takes 8 machines 4 minutes to make 8 widgets, how long would it take 100 machines to make 100 widgets? ____ minutes			
	**If not "High", please suggest how to improve:*			

3A	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 16 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days.			
3B	In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 12 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days.			
	**If not "High", please suggest how to improve:*			
4A	In the example shown below the area of the shape shown on the left is decreased by removing a unit square. If the area of shape on the left is decreased by removing unit squares will the perimeter always decrease? Yes ☐ No ☐ 			
4B	In the example below the area of the shape shown on the left is increased by adding a unit square. If the area of shape on the left is increased by adding unit squares will the perimeter always increase? Yes ☐ No ☐ 			
	**If not "High", please suggest how to improve:*			

5A	Two boxes shown BELOW, A and B, each contain black and white balls that are thoroughly mixed. Which box gives a better chance of picking a black ball at random, without looking?			
5B	Two boxes shown BELOW, A and B, each contain black and white balls that are thoroughly mixed. Which box gives a better chance of picking a black ball at random, without looking?			
	**If not "High", please suggest how to improve:*			

Guilford Alternative Uses Task (Divergent Thinking)		**Equivalence**		
Instructions: *For each pair of items (e.g., 1A and 1B), please use the three-point scale on the right to indicate their degree of* ***equivalence****. That is, the extent to which you believe the two items are equal or interchangeable in requiring the same type and level of creativity thinking and/or problem-solving skill to solve.*		**Low**	**Moderate**	**High**
1A	Please list as many possible uses for a **brick**:			
1B	Please list as many possible uses for a **shoe**:			
	**If not "High", please suggest how to improve:*			
2A	Please list as many possible uses for a **paperclip**:			
2B	Please list as many possible uses for a **newspaper**:			
	**If not "High", please suggest how to improve:*			

Original Items? (Convergent Thinking)		**Equivalence**		
Instructions: *For each pair of items (e.g., 1A and 1B), please use the three-point scale on the right to indicate their degree of* ***equivalence****. That is, the extent to which you believe the two items are equal or interchangeable in requiring the same type and level of creativity thinking and/or problem-solving skill to solve.*		**Low**	**Moderate**	**High**
1A	A man bought a product for $6 and sold it for $7. Then he bought the **same** product for $8 and sold it for $9. What is his total profit?			
1B	Two New Zealand coins total 30 cents. One of them is **not** a 10-cent coin. What are these coins?			
	**If not "High", please suggest how to improve:*			
2A	There are 10 New Zealand and 10 Australian coins of similar size and weight in a box. You take the coins out of the box without looking at them. What is the smallest number of coins you need to take out of the box to be absolutely sure that you have 5 coins of the same country, either New Zealand or Australian?			
2B	There are 60 coins of similar size and weight from different countries in a box: 30 American, 20 Australian and 10 New Zealand. You take the coins out of the box without looking at them. What is the smallest number of the coins you need to take out of the box to be absolutely sure that you have 10 coins of the same country?			
	**If not "High", please suggest how to improve:*			
3A	High in the mountains, three mountaineers needed a fire to make hot drinks. They built a fire and shared it equally. The first contributed 3 pieces of wood and the second contributed 5 pieces. The third person did not have any pieces of wood so he gave $8 to the other two. How should they divide the $8 in a fair way?			
3B	Three backpackers cooked rice for dinner and shared it equally. The first gave 400 g of rice and the second 200 g of rice. The third backpacker did not have any rice so he gave $6 to the other two. How should they divide the $6 between them in a fair way?			
	**If not "High", please suggest how to improve:*			
4A	The price of a product was raised by 10%. Later it fell by 10%. Did it become: a) cheaper; b) more expensive; c) the same price)?			
4B	Which is the bigger reduction: a) 30% cut; b) 20% cut followed by a 10% cut; c) the same?			
	**If not "High", please suggest how to improve:*			

Focus Group Interview (interviewer version)

Task 1 (25 min)

Discuss and solve in a small group (3–4 people) the following puzzle from real job interviews used by Microsoft for many years:

Crossing the Bridge. Four people—John, Paul, George and Ringo—are at one side of a gorge connected to the other by a rope bridge that can only carry two people at a time. It is a night time, so whoever is crossing must use a torch. The group has a single torch, and the gorge is too wide for them to be able to throw it from one side to the other, so the torch must be walked back and forth over the bridge as the people cross. John can cross the bridge in 1 minute, Paul in 2, George in 5 and Ringo in 10. If two people cross together, they walk at the speed of the slowest of the two. How do the group cross the bridge in the quickest possible time? What is the quickest time?

Please write answers to the questions below when asked by the interviewer:

1. What is your preferred way of working on a puzzle such as this? **At start after reading**
2. What do you consider important in order to solve this puzzle? **After 3 minutes**
3. What is your initial aim in order to solve this puzzle? **After 3 minutes**
4. What is your strategy for solving this puzzle? **After 6 minutes**
5. How did you decide what to do first? **After 6 minutes**
6. What is your goal at this moment? **After 12 minutes**

   A possible comment after about 14 minutes if the solution is 19 minutes:

   Your solution of 19 minutes is not the quickest time. You can do better. Try 99 minutes instead of 5 for George and 100 minutes instead of 10 for Ringo. This can prompt you to consider another plan to cross the bridge.

7. What strategy did you use in the end and why did you choose it? **At the end**

Task 2 (25 min)

In a small group (3–4 people) make up an interesting problem based on the information below. You may add extra information if required.

A car, A, is travelling due East at 30 km/h. A second car, B, is travelling South West at 50 km/h.

Write your problem here:

Please write answers to the questions below when asked by the interviewer:

1. Do you have a preferred way of working on a task such as this? **At start after reading**
2. What do you consider important in this task? **After 3 minutes**
3. What is your initial aim in this task? **After 5 minutes**
4. What was your strategy for producing the problems? **After 15 minutes**
5. How did you decide what to do first? **After 15 minutes**
6. What was your goal in producing the problems? **After 15 minutes**
7. What strategies did you use to produce your problems why did you choose them? **After 20 minutes**

Task 3 (10 min)

In a small group (3-4 people) discuss the following questions and write your answers when asked by the interviewer:

1. Is there any connection between the ability to solve puzzles and innovative thinking? Can you give any examples? **At start**
2. How would you describe the type of thinking you use when you are solving a puzzle? Is it the same as you use to solve a routine question? **After 3 minutes**
3. Can you use puzzle solving skills in other areas of life? If so, in what way? Can you give examples? **After 6 minutes**

Lecturer Questionnaire

a) What is your perspective of the puzzles?

b) How did you use the puzzles in the project?

c) How did you feel about teaching the puzzles?

d) Did you change your teaching?

e) Did you change your feelings about the puzzles?

f) Were the puzzles useful for student learning?

g) Did you observe any change in creativity of the answers over the time you used puzzles?

h) To what extent were students engaged with the puzzles? Any evidence of engagement? Did their engagement change over the time?

i) Did you observe any change in the intuitive nature of the students' initial attempts to answer the puzzles over the time?

j) Could the puzzles be improved in any way? If so, how?

Class Observation Protocol

Fidelity of Implementation Observation Protocol

Time					
Dosage	**Start time**	**Stop time**	**Total Minutes**		**Comments**
Time spent on puzzles (non-routine problems)					
LoU= Level of Use					
Adherence	**1=Non Use**	**2=Use**	**3=Adapted Use**		**Comments**
Prescribed content					
Prescribed pedagogy					
Quality of Delivery					
Delivery	**1=Low**	**2=Low Medium**	**3=Medium**	**4=Medium High**	**5=High**
***Active Engagement*:** The extent to which students are actively engaged.					
Clarity and Accuracy: The extent to which the problem or puzzles are presented clearly and accurately.					
Procedural Practice: The extent to which students have time to practise solving the problems or puzzles.					
Organisation: The extent to which the lesson as a whole is clearly organised.					
Positive Affect: The extent to which the teacher demonstrates enthusiasm during the activity.					
OVERALL COMMENTS					