# Comments on the design of the questionnaire

The design of our questionnaire was guided by the following aims:

* To elicit students responses that are pertinent to the affective domain characteristics capturing students feelings, beliefs and attitudes towards non-routine problem solving;
* To encourage students to expand their responses into narratives about their attitudes in each of the four dimensions by prompting them to provide answers in an open-ended way (e.g. a ‘Yes or No’ question was followed by ‘Why?’ or “Please give the reasons’);
* To maximise the response rate within the appropriate sampling frame by surveying students during a lecture to ensure that we capture responses from the students who were exposed to the intervention (students who chose not to attend lectures during the semester did not have to solve any non-routine problems as part of their course assessment). Hence, one of the characteristics of the population in this study is a student cohort attending lectures;
* To adhere to the restriction imposed by the University of Auckland Human Participants Ethics Committee: we could not take up more than 10 mins of lecture time to conduct the survey.

Given the constrains and conflicting aims, we optimised the design of the questionnaire by making it short and by including narrative-prompting questions in line with recommendation by Di Martino and Zan (2015) to shift attitude research away from Likert-style instruments toward the use of narratives. Conducting survey in class on the appropriate population as an anonymous paper based questionnaire (without lecturers present) removed biases associated with a potential reactivity of subjects, which is an affect that can influence students’ narratives during face-to-face interviews with a researcher.

# Questionnaire

Question 1. From your point of view, what are the main differences between puzzles and routine problems/questions?

Question 2. Do you feel confident solving the puzzles?

Yes b) No Please give the reasons:

Question 3. Do you think solving the puzzles can enhance your problem-solving skills?

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

Question 4. Can solving the puzzles enhance your generic thinking skills?

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

Question 5. Can you see any other benefits for you in solving the puzzles?

a) Yes What are they? b) No Why?

Question 6. Approximately how many puzzles did you solve correctly over weeks 7-12?

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

Question 7. What was your grade in the course pre-requisite to this one?

A+ A A– B+ B B– C+ C C–

Question 8. What is your gender? a) Male b) Female c) Unidentified

Question 9. What is your age group? a) younger than 20 b) 20-30 c) older than 30

Question 10. Are you a domestic student or international? a) domestic b) international

Thank you very much for your responses.

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# Coding: student attitudes towards non-routine problem-solving

For each student, we produced a profile capturing their attitudes towards non-routine problem solving by assigning a value for each theme and then summing the values up within each dimension to come to the conclusion about the overall positive, neutral or negative score for each of the four dimensions of attitude:

* A student’s Vision of non-routine problem solving (differentiating disposition) was assigned a positive rating (+1) if, on balance, the student’s passages within the three themes in the Vision dimension indicated that the student expressed differentiating attitude towards non-routine problem solving by specifying key differences such as requiring lateral, creative or ‘outside the box’ thinking, perceiving non-routine problem solving as cracking tricks and differentiating its challenging nature. A negative rating was assigned (-1) if, on balance, the student’s passages clearly expressed the absence of any differences or challenges. A neutral rating (0) was assigned if, on balance, neither of these themes were dominating.
* A student’s Enhancement utility disposition was rated as positive (+1) if, on balance, the student’s responses and passages within the three themes in the Enhancement utility dimension indicated that the student believed that solving non-routine problems can enhance their generic thinking skills, problem solving abilities and can improve their employability prospects. A negative rating (-1) was assigned if, on balance, student’s passages indicated that the student believed that solving non-routine problems during mathematics lectures is useless (waste of precious time) or neutral (0).
* A student’s Emotional disposition was rated as positive (+1) if, on balance, the student’s passages within the two themes in the Emotional disposition dimension indicated a fondness for non-routine problem solving as opposed to an aversion (-1) or neutrality (0).
* A student's Perceived competence was rated as positive (+1), if, on balance, the student's responses and passages within the Confidence theme and the Competence development theme indicated perceived controllability of actions and outcomes in regards to self-efficacy expectations and their ability to develop competence (e.g. students’ passages stating that they can become competent in non-routine problem solving given enough practice and/or time) pertaining to mastery experience. A negative rating (-1) was assigned, if on balance, a student’s response indicated a lack of perceived controllability of actions and outcomes pertaining to non-routine problem solving (e.g. I am not good at math puzzles) or neutral (0) rating, if neither or both.

# Vision of Non-routine Problem Solving (Differentiating from Routine Problem Solving) Dimension

The Vision dimension consists of the three themes: the Lateral thinking/creativity theme, the Trick theme and the Challenge theme. These themes were identified as the three major categories from the analysis of the students’ responses with a focus on whether or not a section from a response (passage) indicated that a student expressed differentiating attitude towards non-routine problem solving by specifying key differences. As with other themes, the passages that were grouped within these three themes stemmed from a variety of questions. Here are examples of passages that were given a +1 or a –1 on these themes with the indication of the prompting question (see Appendix for questions):

* Q#1: “Lateral thinking, using a side of my mind that is, surprisingly, rarely tested at uni” (+1 rating on Lateral thinking/creativity theme)
* Q#1: “Puzzles tend to have a creative, original component that challenges you to think "outside the box", often not the same every time you complete them. While the routine problems/questions tend to have using answers which can be learnt” (+1 rating on Lateral thinking/creativity theme)
* Q#1: “I think puzzles generally require more lateral thinking than routine problems or questions, and the answer that usually seems obvious is most likely wrong” (+1 rating on Lateral thinking/creativity theme)
* Q#1: “No differences” and from the same student Q#2: “Easy” (-1 rating on Lateral thinking/creativity theme and -1 rating on the Challenge theme)
* Q#1 “Puzzles are trickier, and often are deceiving” (+1 rating on the Trick theme)
* Q#2: “Yes; Usually common sense but always suspect they are trick questions” (+1 rating on the Trick theme)
* Q#2: “No; I always feel like there's a trick I'm not noticing and doubt myself. If they're more visual, like the cat one, I find those easier” (+1 rating on the Trick theme)
* Q#2: “No; always some trick that got me” (+1 rating on the Trick theme)
* Q#1: “Forces to apply knowledge, out of the box thinking approaches. It challenges the way you conventionally think” (+1 rating on Lateral thinking/creativity theme and +1 on the Challenge theme)
* Q#1: “Puzzles give a challenging question that encourage us to use our brain” (+1 rating on the Challenge theme)
* Q#1: “Puzzles are challenging in that you have to adopt more abstract approaches when solving them, casting assumptions aside” (+1 rating on the Challenge theme)
* Q#3: “Yes; Some are challenging & require us to think & use our problem solving skills” (+1 rating on the Challenge theme)
* Q#4: “Yes; Constant challenge is essential to developing your thinking” (+1 rating on the Challenge theme)
* Q#5: “Yes; They are challenges. Using different approaches to figure things out” (+1 rating on the Challenge theme)
* Q#2: “Yes; I found them to be mostly straight forward to solve” (-1 rating on the Challenge theme)

# Enhancement Utility Dimension

The Enhancement utility dimension consisted of the three themes: Problem solving, Generic thinking and Employability. These themes emerged as the three major categories that we identified from the analysis of the students’ responses with a focus on whether or not passages indicated that a student expressed an opinion in regard to usefulness of non-routine problem solving. As with other themes, the passages that were grouped within these three themes stemmed from a variety of questions. In many cases the prompting questions Q#3 and Q#4 elicited “Yes” or “No” responses that were used as indicators of the students’ attitudes in regards to the enhancement utility in the Problem solving theme and in the Generic thinking theme, respectively. The Employability theme contains passages in which students discuss puzzles as being useful for employment prospects, job interviews, and real-life practical applications. Here are examples of passages that were given a +1 or a -1 on these themes with the indication of the prompting question (see Appendix for questions):

* Q#4: “Yes; Problem-solving. At the end of the day, that's why people pay other people: to solve problems they can't. It underpins the fabric of the working world” (+1 rating on the Problem solving theme, +1 rating on the Generic thinking theme (because of the “Yes” response to Q#4 about generic thinking), and +1 rating on the Employability theme)
* Q#3: “Yes; By not always thinking inside the square, practicing thinking beyond the obvious enhances skills” (+1 on the Problem solving theme)
* Q#3: “No; I don't see the relation between the two” (-1 rating on the Problem solving theme)
* Q#3: “No; I think they can because they make you think quite outside the box, whereas maths is usually solving problems with a distinct set of rules” (0 rating on Problem solving theme since the “No” response to the prompting question is followed by a contradicting statement”)
* Q#3: “Yes; For future problem solving skills in job interviews” (+1 rating on the Problem solving theme and +1 rating on the Employability theme)
* Q#4: “No, Wouldn't apply any of these to everyday life” and from the same student Q#5: “Chews class time when you could actually be learning something” (-1 ratings on the Generic thinking theme and the Employability theme)
* Q#5: “Yes; Solve real life problems/scenarios” (+1 rating on the Employability theme)

# Emotional Disposition Dimension

Pekrun and Linnenbrink-Garcia (2012) argued that the consideration of functions of emotions for students’ academic engagement needs to be conducted along three dimensions. In addition to valence (positive or negative emotions) and their activation/deactivation characteristics, researchers need to consider their object focus (activity-related focus or outcome-related focus). In our study, we were concerned with students' emotions with regard to a particular task: non-routine problem solving during 5 minutes of a lecture. Hence, it was fitting to group students’ passages into two themes: Enjoyment (positive rating: puzzles are fun, I like them, joyful break in a lecture, pride) and Engagement (positive rating: puzzles are interesting, puzzles are engaging). These two themes align somewhat with a subset of Pekrun's (2006) three-dimensional taxonomy of achievement emotions. Specifically, the Enjoyment theme's rating of +1 corresponds to positive activating emotions (e.g. enjoyment, pride, anticipatory joy) and the -1 rating corresponds to negative activating emotions (e.g. frustration, anger). With respect to this mapping into Pekrun's taxonomy, our Enjoyment theme included his activity-related emotions and outcome-related emotions (both prospective and retrospective). For example, a student’s passage “I enjoy them and helps stimulate my brain which makes me feel good and intelligent about myself and puzzles” can be viewed as an expression of an activity-related emotion (enjoyment of puzzles) and as an outcome-related/retrospective emotion (pride)—both are positive activating type, according to Pekrun's classification. In this case the student's score on the Enjoyment theme was assigned a +1 value. As with other themes, the passages that were grouped within this theme stemmed from a variety of questions. Here are other examples of passages that were given a +1 or a -1 on the Enjoyment theme with the indication of the prompting question (see Appendix for questions):

* Q#1: “Puzzles are for fun, problems are to fix a problem” (+1 rating)
* Q#1: “Puzzles are more hypothetical. I guess they're more often undertaken for enjoyment rather than because you have to” (+1 rating)
* Q#2: “Yes; I feel like it is something I am apt at as I enjoy them” (+1 rating)
* Q#5: “Yes; Enjoyment and satisfaction” (+1 rating)
* Q#5: “Yes; Having a break from the lecture to think about other material” (+1 rating)
* Q#5: “No; Chews class time when you could actually be learning something” (-1 rating)
* Q#5: “No; Puzzles are great, but during a time and a place. I generally didn't care for the puzzles and wanted to get on with the lecture” (-1 rating)

The Engagement theme contains passages in which students stated that puzzles are interesting and engaging. For example:

* Q#1: "Problems are for solving and often a solution to a problem posed by the question. Puzzles are more intuitive and for fun - more like solving riddles and discovering secrets - more like an adventure" (+1 rating)
* Q#1: "Puzzles are not examples, also more interesting. I love puzzles" (+1 rating)
* Q#3: "Yes; Lateral thinking! Big believer in it. Check out CIE AS and A-level thinking skills. Similar stuff. Real engaging" (+1 rating)
* Q#5: “Yes; They are engaging, promote discussion” (+1 rating)
* Q#5: "Yes; Change from monotony of lecture" (+1 rating)
* Q#5: "No; Because I don't participate in them in class puzzles" (-1 rating)
* Q#5: "No; You can't use them often & no one really gets the answer" (-1 rating)

# Perceived Competence Dimension

The Perceived competence dimension consists of the Confidence theme and the Competence development. Our analysis focussed on the students’ control appraisals pertaining to the perceived controllability of actions and outcomes in regards to non-routine problem solving (see Pekrun’s (2006) control-value theory). Students’ “Yes” or “No” responses to Question 2 indicated their action-control expectancies which are expectancies that an action can be initiated and performed by the individual (also known as Bandura’s (1977) “self-efficacy expectations”). That was recorded by the value in the Confidence theme. The Competence development theme contains students’ passages regarding their ability to develop competence through mastery experiences (for example, students’ passages stating that they can become competent in non-routine problem solving given enough practice, and/or time). Majority of the ratings in this dimension were derived from the “Yes/No” responses to Question 2 and the corresponding comments. Here are some examples of the passages with the identification of the question that they correspond to:

* Q#2: "Yes; Reasonably, many puzzles were logical in the answers, and I think with enough practice thinking and approaching them in this manner would build confidence also" (+1 rating for the Confidence theme and +1 rating for the Competence development theme)
* Q#2: "No; Not get, I think if I had more practice it might be easier" (-1 rating on the Confidence theme (since the student answered “No” to the question “Do you feel confident solving the puzzles?” and +1 rating on the Competence development theme, hence the balancing overall 0 rating on the Perceived competence dimension)
* Q#2: “No; Often outside of my skill level, I'm not a very creative thinker” (-1 rating on the Confidence theme and -1 rating on the Competence development theme)
* Q#4: “Yes; After solving several puzzles and seeing the different methods for solving them, they may become ingrained in my thinking and allows me to utilise them in other puzzles in real life” (+1 rating on the Competence development theme)
* Q#2: “No; I am not very creative” and from the same student: Q#3: “No; I think puzzle solving abilities are very much inherent to a person. I just can't solve them” and Q#4: “No; I've solved many puzzles but my creativity has not increased” and Q#5: “No; I might get better slightly at puzzles but it'd most possibly be done to routinized solving & seeing familiar puzzles solved before, so in a way it's not going to help me be more creative” (-1 ratings for the Confidence theme, Competence development theme, Problem solving theme and Generic thinking theme)