Project Title

Assessment Selection Methodology — Low SES recruitment

Contributors

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1 Aims and background

Admission to University studies is currently predominantly determined by a student's Australian Tertiary Admission Rank (ATAR). While there is some evidence to suggest that the highest-ranking ATAR students are generally successful at the University level, the bulk of the remaining rankings cannot be used to make reliable predictions[14]. Moreover, there is general consensus that the ranking does not identify students with promise who come from disadvantaged backgrounds[12;3].

In principle the ATAR is supposed to measure a student's capacity to demonstrate a knowledge base that has been acquired over several years of study. However, what is often overlooked in the analysis of ATAR scores is that the scores also reflect *opportunities* to acquire knowledge. Unsurprisingly, opportunities vary across the spectrum of social and economic backgrounds. In particular, low socioeconomic students face numerous additional life challenges, pressures and difficulties throughout their high-school studies than other students[11;2]. The hardships they face in their personal life introduce a downward bias in their final ATAR. It is very likely that many low socioeconomic students could have achieved more if they had access to better facilities and a stable environment. It is also very likely that a substantial number of such students could excel at university studies.

Problem 1. The existing university admission protocols cannot be used to identify low socioeconomic students that have latent unexplored abilities suitable for university study[11;21]. The inability to distinguish such students stems from the fact that the ATAR scores give no insight into a student's capacity to acquire new knowledge when immersed in a stable, supportive and world-class university environment. Moreover, the ATAR scores cannot be used to differentiate inquisitive, resilient or creative students.

In light of the limitations associated with established protocols, the proposed project aims to develop a whole new framework that can be used to select students that are most likely to succeed at University. Unlike ATAR, the emphasis of the assessment is not primarily on performance or on obtaining the 'right answer'. Rather, the purpose of the assessment is to characterise the thought process that goes into solving a particular task. Considerable research suggests that attributes such as 'creative thinking', 'strategic planning', 'noticing' and the capacity to handle increasingly abstract ideas are strong indicators of intellectual maturity. These attributes have also been identified as cornerstones of the scientific method, and are of particular relevance for admission to STEM courses.

The key innovations of the project are: (1) a development of evidence-based criteria that will be used to identify students with potential, (2) a new set of tasks and activities that require these important characteristics, and (3) the development of a novel framework that can quantify thought processes as opposed to just evaluating the correctness of solutions.

These three points markedly distinguish the project from existing aptitude and IQ tests that focus predominantly on quantifying how many questions were answered correctly.

2 Attributes associated with the successful pursuit of higher education

For many years extensive multi-disciplinary research projects have tried to obtain a deeper understanding of character traits associated with the successful pursuit, acquisition and discovery of new knowledge. While many pertinent questions still remained unanswered, there has also been considerable progress. The diverse research efforts have culminated in the formation of a list of attributes that are commonly believed to be important indicators of a person's willingness and ability to achieve success in tertiary education and beyond. The following sections provide a more detailed account of these attributes.

2.1 Creativity thinking

Perhaps unsurprisingly, creativity is often singled out as integral to any scientific endeavour. However, it is important to keep in mind that the emphasis should not be on creative achievement (e.g. excellence in the arts such as music, poetry, painting or drama), but rather a more subtle notion of *creative thinking*. The reason for this distinction is that science is more than mastering an existing body of knowledge, or following an established set of procedures[7]. Scientific progress requires sustained focused systematic reasoning and directed creative effort. It is precisely this blend that facilitates going beyond existing knowledge and techniques to create new insight and understanding. In support of this notion, the famous physicist and father of quantum mechanics Max Planck once remarked that a scientists must have:

> ... a vivid intuitive imagination, for new ideas are not generated by deduction, but by artistically created imagination[15], p.109.

Creative thinking is what allows a scientist to reach into their repertoire of knowledge and conceptualize novel techniques and solutions[7]. Because the importance of creativity is so widely recognized, there have been numerous efforts in incorporating measures of creativity in teaching and admissions protocols. For example, more than 15 years of data collected from Effective Life-long Learning Inventory (ELLI) project, that was developed in the late 1990s, has identified creative thinking as enabling effective engagement with new learning opportunities[6]. Critical and creative thinking is now part of the general capabilities continua of the Australian curriculum. Regarding admissions protocols, Sternberg demonstrated the importance of creative thinking in his Rainbow and Kaleidescope admissions projects which aimed to predict success at college[20;21;22;23].

2.1.1 Curiosity

A distinct but closely related concept to creativity thinking is curiosity[16]. Curiosity fuels creative thinking—without a dose of curiosity there is no motivation to exert systematic and sustained creative effort to solve a problem. Curious individuals refuse to accept propositions at face value, and generally explore problems more broadly and deeply[6]. According to the ELLI project, they generally learn by working things out and seek to understand each step of a solution[6].

2.2 Practical thinking

Research has also linked practical intelligence with success at university studies. Practical intelligence is broadly defined as acting upon ideas and convincing others of their value. Practical skills include applying, putting into practice, using, implementing and persuading in a real-world context[22]. One can say that an individual displays practical intelligence when they boldly make a genuine attempt to do something, and are undeterred by uncertainty and possible failure.

2.3 Analytical thinking and strategic competence

The term *strategic competence* is frequently used to jointly refer to several interconnected attributes which are described in more detail below.

Problem solving While there is general consensus that the ability to find the correct answer to various puzzles should not be the sole determining factor to predict success at University, puzzles are nevertheless still very valuable. Puzzles afford individuals the opportunity to analyse and reason about problems that require a broad set of quantitative, spatial, probabilistic or other mathematical concepts[13]. Solving puzzles requires substantial mathematical maturity and resolve[17]. In the past problem solving was synonymous with the application of ready-made algorithms to the solution of routine exercises and word problems. Nowadays, puzzles are carefully crafted such that an individual cannot rely on memorization but needs to use not just logic and deduction but also intuition, number sense and inference[13].

Noticing Noticing refers to the tendency to consider details of a problem that are frequently overlooked. Noticing is a reflection of 'intellectual-stretch', that is, an individuals ability to use abstraction to establish relationships between concepts that at face value may seem unrelatable or irrelevant[10]. Noticing is informally associated with the 'Aha!' moment, when crucial connections that facilitate the solution to a problem are established.

Strategic planning Strategic planning can be considered as a trait of an individual's approach to problem solving. It relates to how one's proposed solutions to a problem evolve over time. People who are considered to have strong strategic planning skills typically revisit tacit assumptions they make about a problem in light of new evidence or when they discover their solution is incorrect. Moreover, they tend to spend more time contemplating the correctness of their solution strategy before implementing it. Because they spent more time reflecting on aspects of their solution they are often more aware of the limitations of their approach, and are also cognisant of how they might adapt their solution if the problem was slightly modified.

2.4 Thinking with wisdom

Wisdom is associated with the recognition that the acquisition of knowledge also entails a responsibility to put the knowledge to good use. Knowledge should not only be used for the betterment of oneself but also serve a common good. Wise individuals will contemplate the implications of new knowledge on society and others from both short-term and long-term perspectives.

2.5 Mindful agency

Although creative thinking, curiosity and strategic competence have been identified as important factors contributing to the success at university, effective mindful agency is also of high priority. Without the effective management of time, energy, emotions and actions, university education can be at best challenging, if not impossible[18]. The importance of mindful agency is reflected in the general capabilities continua with self-regulation being taught in the Australian School curriculum. The general capabilities continua classifies self-awareness, self-management, social-awareness, and social-management as being essential for student educational development. The ELLI project supports this notion that mindful agency is a necessary factor for successful learning[5]. The ELLI project describes several behaviours which show students' mindful agency. According to their criteria, students:

1. make conscious choices on how to learn;
2. are thoughtful about intentions;
3. plan and apply effective learning strategies;
4. reflect on personal learning experiences;
5. take responsibility for own development.

3 Project quality and innovation

> "I have always thought the actions of men the best interpreters of their thoughts."
>
> — John Locke, Philosopher

In order to assess the various attributes outlined in the previous section one would ideally know exactly what an individual was thinking as they worked through a problem. Since thoughts beget actions, and actions are observable, we argue that the closest one can come to rationalizing an individual's thought process is by studying their actions. Hence we shall attempt to discover elements of strategic planning, curiosity, creativity and all of the other attributes discussed in the previous section by analyzing an individuals actions across a variety of novel tasks.

Sometimes people learn by doing—they might try a particular strategy only to realise that their strategy does not work or that there may be a better way. An integral feature of strategic planning and mindful agency is to consistently reflect on strategies and modify them accordingly. It stands to reason therefore that the sequence of actions may be the closest one can get to observing the evolution of thought processes over time. In order to gain this previously hidden insight, thought processes would have to be quantified by analysing a sequence of a participants actions over time. However, quantifying a sequence of actions is a challenging problem as it requires sophisticated techniques that are not frequently used in the fields of education and psychology.

3.1 Innovation 1: Quantitative analysis of actions

An important innovation of the proposed project is to interpret the analysis of a sequence of actions as a problem in characterising genetic sequences. In particular, the problem of determining whether two sequences of actions are similar is analogous to the problem of determining whether two nucleotide sequences are similar. Nucleotide sequences are represented by a list of symbols from the English alphabet. For example, given two nucleotide sequences

$$S_1 = GATCACAGGTCTATCACCCT$$

and

$$S_2 = CTATTATTTATCGCACCTACTTAT,$$

a classic problem in Bioinformatics research is to devise a means of determining how similar the sequences are despite the fact that they can have different lengths. Numerous strategies

have been proposed and the method based on characterising the distribution of nucleotides[24] has proven very successful and is easy to implement.

In order to make use of techniques from Bioinformatics research one needs to find a suitable encoding of an individual's sequence of actions on any given problem. The task of determining an appropriate encoding is problem dependent. We shall present plausible encodings for each of the example tasks discussed in the following sections. For the sake of illustration, suppose that the task required a participant to select one of four options (marked as 'A', 'B', 'C', and 'D') to a series of 5 questions that are interdependent. The simplest and most natural encoding would be the sequence of their selections, i.e. $AABAC$, $ABBAC$ or any other length-5 sequence of the four letters.

Once a measure of similarity between sequences of actions has been established, it is possible to apply rigorous statistical methods and data analysis techniques in order to characterise whether a particular sequence of actions reflects 'unusual' insight or novelty. It is also possible to determine how diverse the solution strategies of an individual are. Moreover, because each action is recorded it is possible to step through an individual's actions and play back their sequence of 'moves'. This can be extremely valuable when conducting an interview with the individual, since one can ask direct questions about aspects of their strategy. One can also show unusual strategies and ask for comments, or conduct 'what if' scenarios wherein the individual is asked how they would have changed their solution if they had additional information.

3.2 Innovation 2: Qualitative analysis of active participation

Another important innovation of the proposed project is the incorporation of unusual and intriguing tasks which can only be solved through active participation and may require the use of real-world tools. Furthermore, we have developed a comprehensive rubric to support a reliable and repeatable evaluation of students' efforts.

3.3 Admission tasks

Our admissions tasks are designed to provide students diverse opportunities to demonstrate skills that are associated with success at university. We incorporate both individual and group activities and include communicative, hands-on, deductive and abstract reasoning assignments. In our analysis of a student's performance we focus on finding evidence of ability. A student is not penalised for performing poorly on a task. Rather, they simply miss an opportunity to provide evidence of their latent skill on that particular assignment. They may still be able demonstrate their latent ability on a different task.

3.3.1 Communicative tasks

The *communicative tasks* are designed to measure wisdom and mindful agency, with an emphasis on communicative ability.

Sternberg's essay task The Rainbow and Kaleidoscope projects are two celebrated and successful American colleague admission endeavours at Tufts University. These two admissions projects utilised novel essay questions develop by Sternberg. Students' responses to the essay questions turned out to be superior indicators of undergraduate performance compared to standardised admissions tests and general intelligence testing. For these reasons we chose to include a modified version of Sternberg's essay question. The question that we selected was structured to elicit aspects of wisdom and mindful agency. In particular the question is:

> Engineers and scientists like astronomer Edwin Powell Hubble discovered new solutions to contemporary issues. "Equipped with five senses," Hubble said, "man explores the universe around him and calls the adventure science."
> Identify something that you find interesting and would like to study. How would you go about your study? Why do you think it would be adventurous? How might your research affect the lives of other people? Could you anticipate any things that could go wrong?

Community of inquiry task Many challenging problems cannot be resolved by a single person working in isolation. A genuine solution to a problem often only starts to take shape when many minds have wrestled with the problem, each mind discovering and shedding light on different aspects. The notion of community of inquiry emphasises that education is the outcome of participation in a teacher-guided community of inquiry. Furthermore, the educational process is not seen as information acquisition but rather a grasp of relationships among disciplines. From the community perspective, integral aspects to knowledge transfer and learning are solid communication and listening skills. In the community of inquiry task students will be split into groups and given a broad problem to discuss. Each student will be issued with several tokens and each token affords the student an opportunity to speak. Student have to listen to each other and use their tokens wisely in order to maximise the value of their ideas and contributions to the discussion

Qualitative evaluation Students will exhibit a high level of mindful agency if they communicate thoughtfully and constructively. For example, they will address the essay at a deeper level and may attempt to offer many different points of view. In the community of inquiry task they will try to build on ideas of others and potentially introduce new perspectives into the discussion. Poor mindful agency will be evident in students that write a superficial essay

just to 'get-it-over-with'. They may also not participate in the discussion, or conversely, try to dominate the discussion by using all of their tokens all at once. This means that they will probably not build on the ideas of others, because they do not have the patience to allow the ideas to develop and come to fruition.

Wise students will be able to make clear connections between essay or discussion topics and real world scenarios. They will also be able to give clear and complete explanations of how issues may change over time as values and perspectives change. Students that show little wisdom will struggle to make connections between topics and real-world scenarios. They may not be able to appreciate different points of view and may fail to make any positive or thoughtful contributions.

3.3.2 Hands-on tasks

We test practicality and creativity by using two open-ended *hands-on* tasks.

Sugru task In the first task students are issued with moldable plastic called *Sugru* which hardens after 24 hours but remains bendable. They are posted the Sugru a week before their evaluation. During this time they are supposed to create an item that is both creative and practical. They are instructed to take a picture of their item or to bring the item with them for evaluation. They will then be given the opportunity to showcase their item and motivate it during an interview. Because Sugru is moldable it has numerous potential applications, including mending frayed cables and mounting objects. There is therefore tremendous potential for creativity and for solving or fixing a real-world problem.

Design task In the second task students are shown a picture of the popular X-box gaming controller. They are told to invent a completely new concept for a controller that can be used by someone who is born with no hands (their arms end at their wrists). The new controller needs to support the same functionality that is currently captured by the buttons and thumb-stick of the existing controller. This task has been designed by Prof. David Hobbs and is currently used as an introductory activity for first year engineering students at Flinders University.

Qualitative evaluation Highly creative students will tend to produce something that is very imaginative and intriguing. It will be evident that a lot of thought has gone into the aesthetics of the product. For example, for the Sugru task the item will make insightful use of resources such as magnets, lego, toothpicks or other tools. On the other extreme, disinterested students might recreate someone else's idea and the final product will look dull and uninspiring.

Students can demonstrate practicality by showing that careful thought has gone into the solution and functionality of the final product. For example, for the Sugru task the product could work flawlessly and serve its intended purpose. For the Design task the feasibility of the controller needs to be evident in a simple clear design. If the solution is based on an infeasible or overly complicated and imprecise design the student shows poor practical skills. Poor practical skills will manifest in the Sugru task when the item looks like a desperate attempt to tack Sugru on to something. In the Design task poor practicality will be evident when little thought has gone into the implications of the design.

3.3.3 Deductive tasks

We test analytic and strategic planning ability with two tasks that require deductive reasoning.

Logic puzzle task The first task is a classic logic puzzle:

> Four married couples, Mr. & Mrs. White, Mr. & Mrs. Green, Mr. & Mrs. Brown, and Mr. & Mrs. Black had dinner together. They sat at the round table in such a way that men and women alternated, but all married couples were separated. Mrs. White sat between Mr. Green and Mr. Black, with the latter one sitting to the right of Mrs. White. Mr. White sat next to Mrs. Black.
>
> *Who was sitting to the right of Mrs. Green?*

Scheduling tasks The second task is a scheduling problem. Scheduling tasks provide an excellent opportunity to explore an individual's strategic planning and analytic attributes. Scheduling tasks are encountered frequently in numerous real-world scenarios. Examples include small businesses that need to manage their stock supplies, to large corporations such as Amazon that need to find the most cost-effective strategy for distributing a variety of goods around the world. Scheduling problems usually have many potential solutions and finding the best possible solution requires considerable planning, continual revisions of proposed solutions and creative exploration of the solution space.

An example of a scheduling task is presented in Figure 1. In one embodiment of the task, an individual has a truck at their disposal and has the option of collecting two items (marked for delivery) and transporting them to a factory. Upon delivery the factory will pay \$20 for the first item and \$10 for the second. Each move on the grid costs one dollar in fuel. The objective is to make as much profit as possible. This involves determining the shortest delivery path and additionally deciding whether it is more profitable to deliver both items or just one. It is possible to easily generate numerous variations of this task, by changing the value and

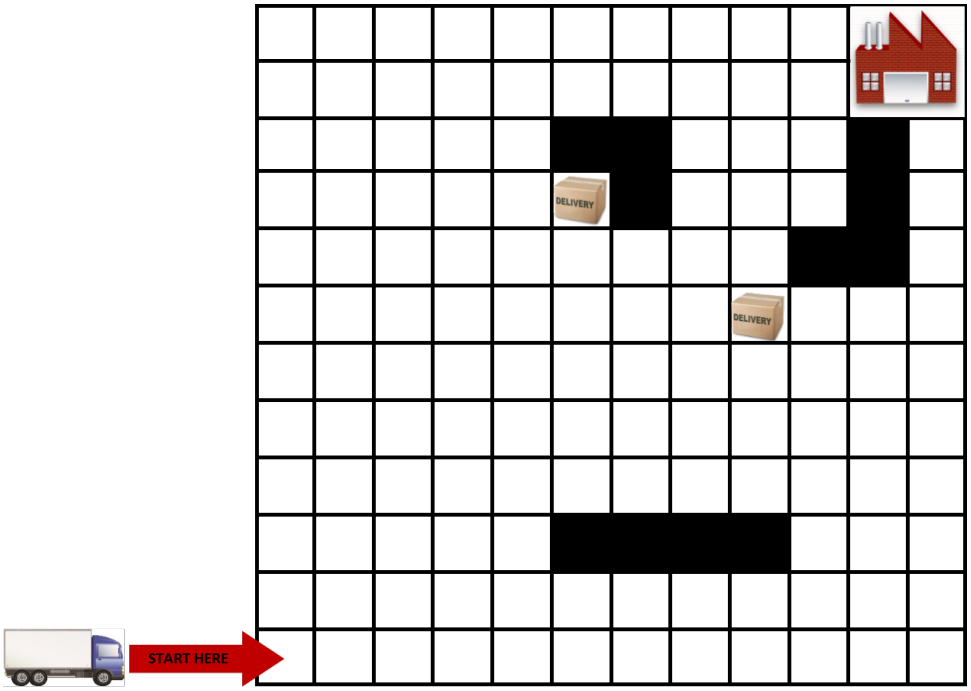

Figure 1: Example of Scheduling task. The objective is to collect items and deliver them to the factory. Each move on the grid costs a dollar in fuel. The factory pays different amounts for each item. In order to make the most profit, an individual has to decide on the shortest path and also determine whether it is better to delivery both items or just one.

locations of the items and introducing additional barriers which the truck cannot drive over. An individuals inclination for strategic planning and competence can be characterized by analysing their solutions across several such scheduling tasks.

The task could be conducted by having the participant play a game on a computer. The computer would facilitate keeping track of all of the moves. The participant can move their truck on the grid using the arrow keys (up (U), down (D) , left (L) and right (R)), and the encoding of their strategy is simply a matter of keeping track of their moves, e.g. $UUUURRRUUURULUR$.

It is also possible to create a pen-and-paper variant of the task, in which participants enumerate the path of the truck by numbering the squares that are visited in sequential order.

Qualitative evaluation Highly analytic students will try to differentiate between important and unimportant information. They will consider how the variables under question compare or influence each other. For example, for the logic puzzle they may say things such as: “If Mrs Green is sitting here then…”.

Furthermore, if they demonstrate a clear process in addressing the problem in a systematic and

methodical manner they exhibit strong strategic planning skills. Their solutions for the scheduling task will sometimes include both deliveries and sometimes not, depending on whether it is actually worth making the second delivery.

Poor strategic planning and analytic skills will be accompanied by an unstructured, chaotic approach where not much thought is given into how variables compare or influence each other. Furthermore, students may also fail to manage their time and fail to complete the task.

3.3.4 Abstract reasoning task

Our approach to gauging abstract reasoning ability is based on a series of novel association tasks.

Association tasks with multiple taxonomies An associations task could be used to establish specific qualities of strategic competence, such as noticing. Noticing has been identified as being a valuable skill for entrepreneurship, mathematical competency, and high level abstraction[9;10;19]. The association tasks that we propose are designed to identify an individual's potential to make unusual connections between concepts. Our association tasks are constructed using multiple taxonomies[8], so there is more than one 'correct' answer based on what point of view (taxonomy) one utilises.

An example of a noticing association task is presented in Figure 2. Given a set of four images, participants are asked to group them into two groups. Based on what they 'notice' there are different possible and equally valid groupings. For example, if participants take a biological perspective than a Dalmatian and wolf belong in a group because they are both canine, and Siamese cat and leopard into another because they are both feline. If participants base it on appearance, then Dalmatian and leopard belong together because of spots and the wolf and cat because of the pointy ears. Lastly, if participants base it on habitat, Dalmatian and cat belong together because they are both domestic animals and the wolf and leopard belong to the same group because they are found in the wild.

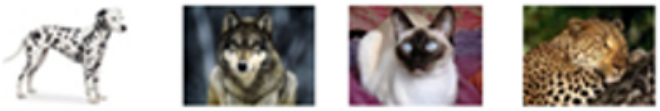

Figure 2: Participants are given a set of four images and asked to group them into two groups.

Upon issuing the task to many participants, it is possible to compute the frequency with which a particular taxonomy is utilised. Figure 3 demonstrates a hypothetical example, in which the biological taxonomy was utilised by most participants. The habitat perspective was taken by

relatively few students. The relative frequency provides a natural measure of novelty. The individuals who used the habitat perspective saw things differently than most other participants. If participants are given multiple different association tasks it is possible to compute their probability to 'see things differently' or 'notice unusual aspects of the problem' by looking at the relative frequency with which their particular choices are shared by the rest of the participants.

Since the problem requires participants to group images it is not difficult to design an encoding of their choices. If we label the 4 images as 'A', 'B', 'C' and 'D', a natural encoding of their proposed groups is to list pairs of letters that form the two groups in alphabetic order. For example, $ABCD$ would be interpreted as AB in group one, and CD in group two. Because alphabetic order is enforced in the two pairs of letters, the choice BA and DC would be automatically reformulated as AB and CD thereby removing the ordering ambiguity in the pairs of letters.

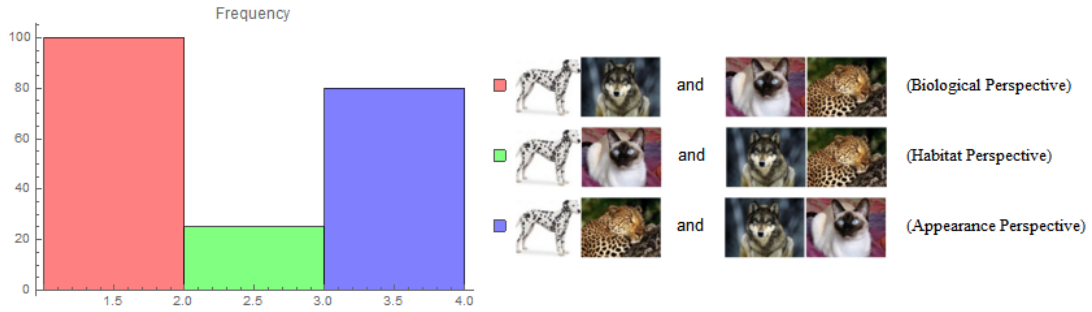

Figure 3: Hypothetical data illustrating an unusual perspective.

Qualitative evaluation Apart from a quantitative analysis of the task, we have also developed a comprehensive rubric to support a qualitative interpretation of students' responses on the association task. In general, students display high analytic ability if they make unusual associations between image pairs. For example, a bat and a killer whale both use echolocation to navigate and communicate. Furthermore, they can typically identify four or more sensible associations between image pairs. On the other hand, poor analytic ability will be revealed when they consistently choose obvious associations. For example, killer whale and stingray are both found in the sea, and a skunk and bat are land animals. Students with poor analytic ability will usually find at most 1–2 sensible associations. They may also try to list non-sensible associations.

If students are willing to give each image pair a go, and try to think of more than one association, they will demonstrate attributes associated with high mindful agency. Further evidence would include persistence in their search for associations until they are satisfied with the number of associations they have found. On the other end of the regulation spectrum are students who,

after having found one or two associations, do not want to think further. They may have also run out of time with the task and not finish the minimum amount of associations.

If the task is done in pairs, we can also assess a student's capacity for mindful agency in a social setting. Students are team-oriented and display high mindful agency if they are able to effectively communicate their chosen associations and explain how they came about these associations. They will tend to give others the opportunity to speak and will communicate in a constructive, helpful and positive way. In contrast, individual-oriented students will display low mindful agency if they dominate the conversation, and do not give others much opportunity to speak. Conversely, they may not want to communicate at all or allow others to dominate the conversation. They may also discuss matters off-topic.

3.3.5 Working memory task

Grasping new concepts requires sustained intellectual effort. Working memory plays an important factor in the ability to exert and maintain a high-level of attention to details. Hence, we incorporated a task that directly measures the capacity of an individuals working memory.

Testing working memory Working memory is an important executive function that is responsible for holding, processing and manipulating transient information. Research on working memory has established that working memory impacts upon comprehension, decision making, problem solving and some intelligence measures[4]. Working memory has also been linked with academic achievement[1], it is plausible that a working memory task may have some predictive power for success at tertiary studies. We shall use a standard working memory task that has been used by many researchers in different contexts. Students will be shown a series of images on a projector for a brief moment, and will be asked to answer questions based on what was displayed. For example, they may be asked to write down where a particular image was located. The task requires students to store a series of relevant and irrelevant images in their transient memory and to recall only the relevant information at a later stage.

Quantitative evaluation We shall follow a standard procedure for evaluating this task which is based on the accuracy of the responses.

4 Feasibility and benefit

This project aims to use these novel paradigms to collect data from Grade 11 and 12 students in low SES communities in order to identify an individual's potential for creative thinking, practi-

cality, curiosity, strategic competence, wisdom and mindful agency. With several principles in mind, the project is designed to:

1. be egalitarian by giving students from all walks of life a *fair go*;
2. assess different types of thinking;
3. be scalable i.e: reasonable assessment time and man power requirements, statistically powerful, cost effective, does not require expertise to administer;
4. yield both quantitative data for numerical consistency, objectivity and easier comparisons, and qualitative data for a richer understanding.

The basis of the assessment is founded on evidence-based criteria that will be used to assess a student's potential rather than their opportunities to obtain knowledge. We have developed a series of tasks that are challenging and differentiating. Furthermore, we presented details of how a novel framework can be applied to distinguish creative thinkers or noticers from a potentially large sample. Once low socioeconomic students have been identified as having these evidence-based criteria, it is our goal to give these students with promise an opportunity to study at Flinders University. The project also aims to take longitudinal measurements over time to observe the students that have come to university through this alternative pathway. The intent of the observations is to ascertain the impact the proposed selection criteria may have on: retention rates, performance, difficulties and success outside of university. Lastly, it is our goal to establish criteria that are accurate predictors of students success, that bring greater equity to the admissions process, and that can measure essential qualities that standard tests are not capable of measuring.

4.1 Pilot studies

We conducted 16 pilot studies to fine-tune the tasks and ascertain their feasibility and utility. The tasks were issued to Grade 11 and Grade 12 students from schools all around South Australia. The schools were from mixed SES backgrounds, ranging from low to middle income groups. Students were positive and receptive to the tasks that we gave them and provided novel and surprising responses which suggest that the proposed tasks are differentiating and informative of students' abilities. The rubrics that we developed were used to guide the assessment of the tasks by two different markers. Any disagreements in the assessments were discussed and the task was jointly re-evaluated. The rubrics were subsequently reformulated to reduce future disagreements.

5 Evaluation day

The schedule for the evaluation day is as follows:

9:00am Schools transport students to Flinders University. The students are then given an overview of the day and receive instructions on housekeeping rules etc.

9:10am Warm-up activity (30 minutes)

9:40am Controller task (20 minutes)

10:10am Working memory task (20 minutes)

10:30am Association task (30 minutes)

11:00am Break for drinks, snacks or bathroom (15 minutes)

11:15am Community of Inquiry task (30 minutes)

11:45am Essay (30 minutes)

12:15am Lunch (1 hour). Students are invited for a 5 minute interview for the Sugru task.

13:15pm Scheduling task (20 minutes)

13:35pm Logic puzzle task (20 minutes)

13:55pm End of tasks. Students alight buses at 2pm.

Total time: 4 hours and 55 minutes.

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