Development of the Critical Thinking Toolkit (CriTT): a measure of student attitudes and beliefs about critical thinking

Abstract

Critical thinking is an important focus in higher education and is essential for good academic achievement. We report the development of a tool to measure critical thinking for three purposes: (i) to evaluate student perceptions and attitudes about critical thinking, (ii) to identify students in need of support to develop their critical thinking, and (iii) to predict academic performance. Seventy-seven items were generated from focus groups, interviews and the critical thinking literature. Data were collected from 133 psychology students. Factor Analysis revealed three latent factors based on a reduced set of 27 items. These factors were characterised as: Confidence in Critical Thinking; Valuing Critical Thinking; and Misconceptions. Reliability analysis demonstrated that the sub-scales were reliable. Convergent validity with measures of grade point average and argumentation skill was shown, with significant correlations between subscales and validation measures. Most notably, in multiple regression analysis, the three sub-scales from the new questionnaire substantially increased the variance in grade point average accounted for by measures of reflective thinking and argumentation. To sum, the resultant scale offers a measure that is simple to administer, can be used as a diagnostic tool to identify students who need support in developing their critical thinking skills, and can also predict academic performance.

Keywords: Critical Thinking, Learning, Teaching, Cognitive Reflection, Questionnaire; Argumentation; Dual Process Theory

Introduction

Critical thinking has a central role in learning (Beyer, 1987; McPeck, 1981), and is regarded as a "core outcome in higher education" (Lederer (2007, p. 525). At university, critical thinking is essential to meet assessment criteria (Elander, Harrington, Norton, Robinson, & Reddy, 2006), and is associated with employability and academic achievement (Facione, Facione, & Giancarlo, 2000; Halx & Reybold, 2005). Moreover, developing critical thinking skills can also enhance the ability to draw sound conclusions and make informed decisions (Dwyer, Hogan & Stewart, 2014). By developing graduates with critical thinking skills, universities can enhance innovation in the workplace and society (Davies, 2006; Snyder, 2003). However, many students struggle to understand critical thinking, lack confidence in its application, are unsure how they can develop critical thinking skills and struggle to demonstrate them in their assessments.

Critical thinking can be difficult to define concisely, for example, the expert consensus from the American Philosophical Association defined critical thinking as:

"*purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based"* (Facione, 1990, p. 2).

This definition captures the complex, multifaceted nature of critical thinking, which may explain some of the difficulty students face with understanding the meaning of the concept.

Bonnefon (2016) argued that this definition of critical thinking perfectly maps on to the analytic system posited by dual process theorists in cognitive psychology (e.g., Kahneman, 2011). Dual process theories of thinking and reasoning propose a qualitative contrast between 'Type 1' fast, implicit, automatic processes (intuitions or gut-feelings) and 'Type 2' analytic processes which are purposeful, self-regulatory, conscious and effortful. Both Halpern (2014) and Bonnefon (2016) equate critical thinking with Type 2 rather than Type 1 processing. Indeed, Stanovich (2016) argued that the study of critical thinking must be grounded within the cognitive psychology of human rationality as critical thinking is a sub-category of rational thinking. Type 2 processing is associated with working memory capacity and executive function

(Evans & Stanovich, 2013), but also with dispositions, attitudes, beliefs and motivation (e.g., Stupple & Ball, 2014), and willingness to avoid 'miserly' Type 1 thinking (Toplak, West, & Stanovich, 2011). Thus we would expect such factors to be important in critical thinking.

Of note, however, different disciplines tend to emphasize different aspects of critical thinking (e.g., Liu, Long & Simpson, 2001). Garside (1996) considered that critical thinking ability requires the possession of a sufficient knowledge base within a specific subject area to be demonstrated. Jones (2009) further argued that critical thinking was one of several generic attributes that "are conceptualized and taught in different ways" (p. 85) within each discipline. Accordingly, it may not simply be sufficient to possess the subject knowledge to apply one's critical thinking skills, but these skills may need to be conceptualised in a subject-specific way. Thus, in developing a measure of critical thinking, subject-specific considerations can be important as well as more generic critical thinking skills such as reasoning and argumentation. As such, it was our goal to develop a critical thinking measure with students from a specific discipline - psychology.

In the U.K., critical thinking is explicitly referred to in the Quality Assurance Agency's Psychology Benchmarks Statement, which prescribes that multiple perspectives should be presented to foster critical evaluation (QAA, 2007). One of the difficulties both for students and for tutors is that the perceived complexity of critical thinking can make it difficult to communicate effectively about critical thinking and can be a barrier to the learning and teaching of critical thinking skills. In psychology, critical thinking tends to be linked with reasoning, analysis and evaluation of research evidence (Bensley, 1997; Meltzoff, 1998). As a result, guidance about teaching critical thinking in science emphasizes the aspects related to developing skills for reasoning and problem solving (van Gelder, 2005). There is, however, much scope for student misconceptions and misunderstandings at a more basic level about what critical thinking is and how it can and should be demonstrated.

In one study, psychology students and tutors had very different understandings of what is meant by terms such as critical evaluation, development of argument, and use of evidence, with tutors' descriptions emphasizing internal cognitive processes,

whereas students' descriptions emphasized the selection and manipulation of external material (Harrington et al., 2006). Harrington et al. argue that 'critical evaluation' is often understood by students to mean negative criticism with emphasis on weaknesses and limitations, while 'argument' is often understood as an adversarial conflict rather than an academic skill. From this evidence, it is apparent that a measure of beliefs, attitudes and behaviours about critical thinking, specifically targeted at psychology students, would have the potential to offer great benefit.

For example, in a qualitative study Duro, Maratos, Elander, Stupple and Aubeeluck (2013) conducted interviews and focus groups with psychology students and staff. They found a range of attitudes and beliefs regarding critical thinking, which may have the potential to influence the ability of students to demonstrate their critical thinking skills. Students discussed the transitions they went through in understanding the value and expectations of critical thinking, and that they initially had vague understandings of this. Some students believed that 'you have either got it or you haven't', which could be problematic for the development of critical thinking skills. Some students also expressed the view that critical thinking is about identifying limitations and emphasising negative aspects, while others lacked confidence in their critical thinking ability. Overall then it would appear that while great emphasis is placed on critical thinking, there could be a disconnection between learning and teaching strategies and student experiences.

Understanding student critical thinking ability is clearly important and there are a range of generic measures of critical thinking that have been widely used. To date, these measures have tended to focus on problem solving in critical thinking and include the Cornell critical thinking Test (Ennis & Millman, 1985), the OCR AS critical thinking examination (Wells et al., 2006), Thinking Skills Assessment (Black, 2008; 2012) and the California Critical Thinking Skills Test (Facione et al., 1992). Others focus on ill-structured problems, (e.g. the Reflective Judgment Interview, King et al., 1990), or a combination of the above (e.g. the Watson-Glaser critical thinking Appraisal, Watson & Glaser, 1964). Still others have focused on critical thinking dispositions (e.g. the California Critical Thinking Disposition Inventory, Facione et al., 2001). In a recent review, an integrative framework that captures the metacognitive, reflective and memory-based aspects of critical thinking was presented

(Dwyer et al., 2014). This framework is consistent with the views of Halpern (2014), Stanovich (2016) and Bonnefon (2016) presented earlier as there are clearly similarities between the elements of this critical thinking framework and dual process theories of thinking and reasoning (e.g., reflective thinking and metacognitive processes are important in dual process theories of thinking and reasoning). While Dwyer et al. emphasise the aptitude for reflective judgement, inference and analysis they also place importance on the self-regulatory, metacognitive aspects of critical thinking. We argue that existing measures of critical thinking skills, while effective for measuring aptitude, are somewhat limited in scope by an over-reliance on formal reasoning tasks. Studies examining metacognitive factors such as the role of thinking disposition offer a further important perspective, but these do not sufficiently capture student attitudes and beliefs about critical thinking, which have the potential to play an important self-regulatory role. It would therefore be beneficial to utilise a wider range of measures to examine critical thinking, including measures of attitudes and beliefs about critical thinking as well as critical thinking behaviours.

The goal of this study was therefore to develop a psychometrically valid and reliable tool to measure students' attitudes and beliefs about critical thinking in the context of their degree studies. We assessed the criterion-related validity of this new tool in terms of relationships with established correlates of critical thinking: argumentation, cognitive reflection and grade point average. The cognitive reflection and argumentation measures were specifically chosen as they measure Type 2 thinking which theoretically underpins critical thinking (Bonnefon, 2016; Halpern, 2014). Grade point average was chosen as a criterion because we intended the scale to support student academic achievement and because critical thinking is associated with such achievement (Facione, Facione, & Giancarlo, 2000).

The Type 2 thinking measures selected to examine intuitive and analytic thinking were the Argument Evaluation Test (AET) and the Cognitive Reflection Test (CRT). The AET measures two aspects of argumentation that are central to critical thinking: the extent to which judgements of argument strength are determined by pre-existing beliefs (which is indicative of Type 1 thinking) and the extent to which they align with expert ratings of argument strength (which is indicative of Type 2 thinking). The CRT was used to test participants' reflective thinking, and their ability

to inhibit impulsive judgements. It consists of three reasoning tasks and has been shown to negatively correlate with a range of cognitive biases (a composite measure of 15 classic heuristics and biases tasks showed a .42 correlation with avoiding biased responses) and positively correlates (.49) with tasks that require analytic thought (Toplak, West & Stanovich, 2011). Frederick (2005) also found that in samples of college students in the US the CRT is a significant correlate (.44) of SAT score (formerly the Scholastic Aptitude Test, which measures readiness for college level education).

In sum, we predicted that more positive attitudes and beliefs about critical thinking, as measured by the new scale, would be related positively to scores for cognitive reflection and argument-driven responding, and negatively to scores for belief-driven responding. Moreover, it was hypothesised that the scale would predict variance in grade point average.

Method

Participants

The sample comprised 133 psychology undergraduates from the University of Derby, U.K., who were opportunistically sampled. They were aged between 18 and 50 years and there were 98 females and 29 males (six participants did not provide gender information). The students were in the first and second year of their undergraduate studies and represented 49% of the total number of students enrolled on core psychology modules in that semester at the University.

Item generation

Using the transcripts from interviews and focus groups conducted by Duro et al. (2013), themes were examined to develop potential items for the critical thinking scale. Items were generated to reflect the themes produced by both academics and students (as reported in Duro et al.), and through reviewing the critical thinking literature. This resulted in 77 potential items, which represented a range of themes related to critical thinking including: development, confidence, expectations misconceptions and understandings, as well as valuing critical thinking. The 77

potential items were presented to participants with a ten-point Likert scale to indicate extent of agreement (ranging from 'Strongly disagree' to 'Strongly agree').

Validity measures

Measures of argument evaluation, belief biased thinking and cognitive reflection were utilised to test concurrent criterion validity. A modified 19-item version of Stanovich and West's (1997) Argument Evaluation Test (AET) was used as a measure of participants' ability to objectively evaluate the quality of presented arguments. Where necessary items were amended to terminology that would be relevant or familiar to U.K. students. This task presented participants with statements of belief about controversial topics, for example statements such as: "Women should stay home and take care of the children while they are young" were presented and participants were asked to rate the extent of their agreement with this belief on a Likert scale, participants were then required to evaluate the quality of arguments relating to those topics. In the argument evaluation section of the task participants were presented with three elements, for example:

Claim: Only a mother can provide the quality of care young children both need and deserve. *Counterargument*: Women who are in self-fulfilling careers are confident parents who spend as much quality time with their young children as nonworking women. *Rebuttal* to counter-argument**:** Most women work out of necessity, not because they find their employment fulfilling.

Participants were then required to rate the quality of the argument presented in the rebuttal on a four-point Likert scale. For each participant a regression analysis was conducted to examine the extent to which their argument evaluation was predicted by their beliefs (agreement ratings), and the extent that they are predicted by expert panel ratings (from the original Stanovich & West, 1997 study). From these regressions two beta values were produced that indicate: (i) the extent to which participants' judgments about argument strength were influenced by their own pre-existing beliefs (which measures the preference for Type1 intuitive thinking); and (ii) the extent to which they can suppress the influence of their beliefs when analysing the strength of an argument (which measures the preference for Type2 analytic thinking). Stanovich

and West (1997) maintain that in assessing a participant's ability to evaluate arguments the AET examines an essential aspect of critical thinking.

Frederick's (2005) Cognitive Reflection Test (CRT) was presented. In this task participants must generate answers to three reasoning tasks. An example item from the CRT is: "A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost? ____cents". The common but incorrect answer to this problem is 10 cents. The slower, more effortful correct response is 5 cents. Avoiding the intuitive 10 cents response to calculate the correct answer evidences Type 2 reflective cognition. The CRT score was calculated as the total number of correct responses.

Finally, participants' grade point average (GPA) for the semester in which they completed the study was included. The grading scale on which these were based was scored out of 24, where a score of 10 equated to a passing standard and 18 equated to the lowest mark in the first class grade band. The mean average grade for the modules completed in that semester was used. GPA assessed the predictive criterion validity of the scale as the grades were for assessments submitted after participation in this study.

Procedure

Ethical approval for the study was obtained from the university psychology research ethics committee and the study was conducted in accordance with the British Psychological Society Code of Ethics. Students were recruited during teaching sessions and briefed about the study and ethical considerations, before completing the questionnaire and validation tasks in classrooms.

GPA data was consented to separately with ten participants refusing consent for this measure. Participants first completed the belief ratings for the AET, they then completed the candidate items for the critical thinking questionnaire, followed by the argument evaluation element of the AET, and finally the CRT was completed. There were no time limits imposed on participants and the tasks were completed in 'exam conditions'.

Results

For the critical thinking scale a total score was computed as the sum of ratings across all 77 items. Individual items were correlated with the sum total of the scale and were excluded where r<.25 (Everitt, 2006 argues for a cut-off of r=.2 whereas Nunnally & Bernstein, 1994, argue for r=.3 as the cut-off). As a result, 41 items were excluded from further analysis leaving 36 for inclusion in the factor analysis.

Factor Analysis

Principal Axis Factoring (PAF) with Oblimin (Kaiser Normalization) rotation was conducted on the remaining 36 items. The Kaiser-Meyer Olkin measure of sampling adequacy suggested that the sample was factorable (KMO=. 765). Bartlett's Test of Sphericity was highly significant ($\chi^2 = 2635$, df=990, p<.001), and low off-diagonal values in the anti-image correlation matrix provided further evidence that the data were suitable for factor analysis (Tabachnick & Fidell, 2007).

Observation of the scree plot indicated three factors. This was confirmed by a parallel analysis (Horn, 1965) in which only the first three eigenvalues exceeded the criterion values based on 100 random datasets. Therefore, the analysis was re-run specifying the extraction of three factors, which resulted in a parsimonious factorial structure.

The Pattern Matrix was used for interpretation (see Table 1). We set a threshold for factor loadings based on Comrey and Lee's (1992) 'fair' criterion of .45 (see also Tabachnick & Fidell, 2007) and items not meeting this threshold were excluded. There were no cross-loadings observed for items meeting this threshold. Based on these exclusion criteria 17 items loaded on to Factor 1. These items related to self-efficacy and confidence as well as self-reported critical thinking behaviour, and this factor was labelled 'confidence in critical thinking'. Six items loaded on to Factor 2. These items were related to the perceived utility of critical thinking for good

performance in higher education, and this factor was labelled ‘valuing critical thinking’. Four items loaded on to Factor 3, these items related to misconceptions about higher education, critical thinking and conceptual knowledge, and this factor was labelled ‘misconceptions’.

Table 1 here

Reliability

Internal consistency was analysed using Cronbach’s Alpha. The items in Factors 1 and 2 demonstrated high reliability (Cronbach’s ά= .92 for factor 1 and .79 for factor 2). The factor 3 items demonstrated moderate reliability (Cronbach’s ά= .60). See Table 2 for means and standard deviations for the sub-scales. The combination of these factors forms the *Critical Thinking Toolkit* (CriTT). The sub-scales were scored by computing the total of the items. The full questionnaire and scoring instructions are given in the appendix.

Table 2 here

Validation

For the AET, high scores for the Argument driven responding measure indicate stronger argument evaluation skills, whereas high scores for Belief driven responding indicate a reliance on prior belief in judging arguments. It was predicted that Factor 1 (Confidence in Critical Thinking) and Factor 2 (Valuing Critical Thinking) would positively correlate with argument driven evaluation and negatively correlate with belief driven evaluation, as measured by the AET. In contrast, for Factor 3 (Misconceptions) a negative relationship with argument driven evaluation was predicted.

The correlations presented in Table 3 offer statistically significant support for the validity of the three separate CriTT sub-scales as measures of a key aspect of critical thinking - argumentation. Confidence in Critical Thinking correlated negatively with belief driven responding. For Valuing Critical Thinking, there is a correlation between perceived utility of critical thinking and the ability to both evaluate arguments and inhibit prior beliefs. Finally, while there was no significant relationship shown

between Misconceptions and belief-driven responding on the AET there is a highly significant negative correlation between scores on Misconceptions and accuracy of argument evaluation. There is no evidence for the CriTT sub-scales correlating with reflective thinking (CRT) as there were no reliable relationships shown. Further correlations were conducted with grade point averages (GPA). Factor 2 (Valuing Critical Thinking) demonstrated a significant positive correlation with GPA and Factor 3 (Misconceptions) demonstrated a significant negative correlation with GPA. However, Factor 1 (Confidence in Critical Thinking) demonstrated no significant correlation with GPA.

Table 3 here

Predicting performance

To test the efficacy of the CriTT to contribute to our understanding of academic performance we conducted a regression analysis using the CRT, the AET and the CriTT as predictors with grade point average as the outcome variable. This was to examine to what extent the CriTT accounts for variance in academic performance over and above thinking aptitude measures. A hierarchical regression was conducted that included two blocks of variables (See Table 4 for full details). Initially a stepwise block of the validation measures was entered to test which of the thinking skill measures made a significant contribution to predicting GPA – the primary goal of the analysis was not these measures per se, but the extent to which our scale is predictive beyond measures of aptitude. Therefore, only significant predictors from the first block would be relevant to the final model. The second block was the focus of our interest as it tested how much additional variance is predicted by the CriTT subscales (and thus the role of attitudes and beliefs about critical thinking in predicting academic performance).

The analysis found that the CriTT factors, combined, significantly predicted variance in the grade point average in addition to that predicted by the aptitude based measures. In the first block the Argument Evaluation Test scores were excluded due to falling under the threshold for inclusion leaving only the CRT in the model. The CRT was a highly significant predictor and accounted for 8.3% of variance in GPA. The addition of the three CriTT factors to the model significantly increased the

variance accounted for by an additional 11% (F-Change 4.89, p=.003). Misconceptions (*p*=.026) and Valuing Critical Thinking (*p*=.049) were both significant individual predictors, however Confidence in Critical Thinking (*p*=.08) approached significance but did not meet the p<.05 threshold. These data indicate that the combination of the CRT and the CriTT subscales accounted for 19.2% of the variance in GPA in our sample. Notably, the combination of the three CriTT subscales more than doubled the variance in GPA accounted for when added to the model and, moreover, made a significant independent contribution to the prediction of grade point average.

Table 4 here

Discussion

The Critical Thinking Toolkit (CriTT) measures beliefs and attitudes about critical thinking. It comprises three factors, which correlated with both theoretical and applied aspects of critical thinking, and were predictive of academic performance. The first factor, 'Confidence in Critical Thinking', measured participant confidence in critical thinking. The second, 'Valuing Critical Thinking', measured the extent to which students recognise the importance of critical thinking. The third factor, 'Misconceptions', measured avoidance of critical thinking or misconceptions of critical thinking. These factors were consistent with reported experiences of students regarding issues of confidence and self-efficacy, perceived utility, and avoidance of critical thinking (Duro et al., 2013).

In terms of the validity of the scale, we found significant correlations between the three factors and scores on Stanovich and West's (1997) Argument Evaluation Test. Here, scoring high on belief-driven responding indicates a Type1 tendency, whereas scoring high on argument driven responding corresponds with a Type 2 tendency, accordingly Type 1 thinking is bias prone and inconsistent with definitions of critical thinking (e.g., Facione, 1990). For example, 'Confidence in Critical Thinking' correlated with the ability to over-ride ones beliefs when considering the strength of arguments (avoiding Type1 thinking). 'Valuing Critical Thinking' correlated with both the ability to over-ride belief, and also with the ability to assess argument strength (applying Type2 thinking). Finally, for 'Misconceptions' we found that these

negatively correlated with the ability to assess argument strength. These correlations show that the CriTT correlates with essential elements of critical thinking ability. Indeed, Stanovich and West characterise the AET as measuring "a quintessential aspect of critical thought" (p. 351) and all of our subscales correlate significantly with one or both measures from the AET. Thus, these analyses demonstrate that the CriTT is a robust, valid and reliable measure of student attitudes and beliefs about critical thinking.

Our second validation measure, the CRT, has been established as correlating with SAT scores and is associated with academic achievement (Frederick, 2005). Importantly, the CriTT reliably accounts for similar levels of variance in GPA to the CRT but is complementary to the CRT. Such that, while the correlations between the factors in the CriTT and the CRT are low and non-significant, when they are combined in the regression model they predict a significant and substantial amount of variance in GPA. This shows that the CriTT and the CRT measure separate things that are independently related to GPA. CRT scores reflect an aspect of ability, whereas CriTT scores reflect beliefs and attitudes. It should be noted that the CRT focuses on a particular aspect of reflective thinking and that a wider set of reflective thinking processes will be important in explaining variation in GPA. The results of the regression analysis nonetheless show that both of these factors predict academic achievement.

The 'Misconceptions' factor identified in the analysis appears to be the least coherent in terms of the items that it clusters together; nonetheless, the combination of misconceptions and poor study habits that it reliably groups together are indicative of avoiding critical thinking, and it has the strongest (negative) correlation with grade point average. This is despite the fact that self-report measures of attitudes and beliefs do not always accurately predict behaviour (e.g., Armitage & Connor, 2001) and confidence in reasoning does not accurately predict performance (e.g., Shynkaruk & Thompson, 2006). Nonetheless, the CriTT scale developed here explains variance in academic achievement in addition to that explained by the CRT.

The goals of this study were to develop a psychometrically valid measure of critical thinking beliefs and attitudes, which could be used to predict academic performance,

identify students who need additional support and facilitate students in reflecting about critical thinking. Teaching staff can use the CriTT to assess the needs of students, in order to identify those who lack confidence in their critical thinking skills, place insufficient value on critical thinking or have misconceptions about it. This would facilitate the implementation of learning interventions to facilitate their development as critical thinkers. These interventions could take the form of confidence building activities, demonstration of the value of critical thinking and challenging misconceptions. An obvious example would be to challenge misconceptions about critical thinking by encouraging positive and negative critique in class activities. Explicit conversations about the importance of critical thinking in achieving good grades as well as introducing step-by-step guides to enable effective critical thinking could be useful activities to include in curricula (see Halpern, 2014; Paul & Elder, 2004 for examples of critical thinking about arguments and assessments). In Duro et al.'s (2013) study, students desired critical thinking to be taught more explicitly– the CriTT could be used to facilitate this and would also allow measurement of whether alternative approaches to teaching critical thinking significantly change beliefs and attitudes about critical thinking.

In addition, the CriTT has the potential to help students reflect on their beliefs about critical thinking. For example, teaching sessions on critical thinking could use the items from the questionnaire to generate conversations that establish the expectations academics have regarding critical thinking, or for students to highlight areas where they have concerns. In the Duro et al. (2013) study some students reported not having previously thought about the concept of critical thinking, the CriTT could be used to encourage such students to reflect on the role of critical thinking in their studies.

Future Directions and Limitations

The evidence for the utility of our measure is good; however, in future studies the scale needs further testing, with a confirmatory factor analysis and an examination of the extent to which the measure can be applied beyond the initial cohort of psychology students. It is, moreover, important to test the factor structure of the CriTT with a wider population of students from a diverse set of UK and international institutions to assess whether the findings associated with the scale are generalisable beyond the present university or discipline.

One interesting aspect of the scale reduction was that all but one of the items that specifically applied to psychology were removed due to low item-total correlations or poor factor loadings. We recommend that the psychology specific item could be re-worded to replace the word 'psychology' with 'my subject' or the name of another subject for use with students of disciplines other than psychology. We were guided in our scale development by the content of focus groups and interviews with staff and students, and later by the outcomes of the Factor Analysis - the absence of questions that specifically mention psychology was a consequence of this empirical approach and raises the question of whether attitudes and beliefs about critical thinking are necessarily discipline specific. Further to this, it should also be noted that this scale development took place in the context of a psychology programme and as such would have been completed with this discipline in mind. We therefore advocate that this tool be evaluated in the context of other disciplines. This would be useful in evaluating whether the CriTT captures beliefs and attitudes about critical thinking that apply more broadly and that facilitate critical thinking in broad terms, or whether this set of items is discipline specific. It has also been established that academic self concepts are domain specific, for example, maths self concept predicts academic performance in maths but is less predictive of performance in other disciplines (e.g., Marsh & Seaton, 2013). Indeed, this presents a further rationale to investigate whether the scale is valid and reliable in samples of students from alternative disciplines and demographic groupings.

The CriTT could be used in educational contexts to explore with students what is distinctive about critical thinking, and the part that critical thinking plays in other aspects of academic thought and feeling, such as academic self-concept (Marsh & Shavelson, 1985). This should help students to understand the benefits of thinking in a more critical way, but also what critical thinking involves. In many ways, 'critical thinking' is implicit in broader constructs of academic thinking and self-concept, but using the word 'critical' (and elaborating on it, clarifying it, and presenting examples) can help students to focus on a key aspect of academic thought in a more deliberative, intentional and conscious way, consistent with Type 2 thinking. A future test for the measure would be to examine the extent to which it may complement more extensive general measures of academic attitudes in higher education such as academic self-

concept (e.g., Marsh, Byrne & Shavelson, 1988). The critical thinking scale measures a narrower construct than academic thinking, or academic self-concept, as it focuses more specifically on beliefs and attitudes related to critical thinking, but future research might assess the relationships among those constructs, and test them as independent predictors of academic achievement. Some work has already been done in demonstrating correlations between the CriTT and Authorial Identity (Cheung, Stupple & Elander, 2015) which measures a further set of important attitudes about studying in higher education that correlate with GPA. This relationship warrants further investigation. Finally, further correlational studies that test the relationship between the CriTT and discipline specific critical thinking aptitude tests could be worthwhile in further exploring its validity.

Conclusion

To conclude, in developing the CriTT scale we have created a psychometrically robust and valid measure of critical thinking attitudes and beliefs. These attitudes and beliefs demonstrate incremental predictive utility over aptitude measures for predicting academic achievement. We argue that engaging with the scale will be beneficial for staff and students through encouraging self-reflection and facilitating engagement with a wider range of critical thinking resources.

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Appendix I. Finalised Questionnaire

Critical Thinking Questionnaire

Please respond to each question. Check the box that best reflects your opinions and please remember there are no right or wrong answers.

		10 **(Strongly agree)**	***9***	***8***	***7***	***6***	***5***	***4***	***3***	***2***	***1*** **(Strongly disagree)**
1	I can detect the use of inappropriate emotional language in scientific arguments										
2	I have a well-defined goal in mind when I am critical										
3	I can identify the structure of arguments without being distracted by their content										
4	Critically thinking is particularly important in psychology [or insert name of discipline]										

5	Critical thinking is essential in higher education
6	When there is a very strong relationship between two variables we can claim that one causes the other
7	Critical thinking develops as you progress through your degree
8	I can express my critical thinking well in my written work
9	You cannot get a good degree without good critical thinking skills
10	I prefer to do things where there is a quick answer
11	I have a focused and systematic way of thinking
12	All relevant information should be presented in lecture slides
13	Generally I am a good critical thinker
14	I do well in assessments that ask for critical evaluation
15	I think critically while working on my assignments
16	All my lecturers expect me to think critically
17	I know how to approach complex issues in a variety of ways

18	I will get higher grades if I think critically
19	I have the ability to judge the value of new information or evidence presented to me
20	I can evaluate the arguments of others well
21	Critical thinking is when you describe what is wrong with something
22	I am good at weighing up both sides of an argument
23	I can identify analogies between theories
24	When designing experiments I can readily eliminate extraneous variables
25	I think critically while reading
26	I can rephrase the arguments of others in my own words easily
27	I think critically in lectures

Scoring key

Factor 1 - Confidence in Critical Thinking

1, 2, 3, 8, 11, 13, 14, 15, 17, 19, 20, 22, 23, 24, 25, 26, 27

Factor 2 - Valuing Critical Thinking

4, 5, 7, 9, 16, 18

Factor 3 - Misconceptions

6, 10, 12, 21

Table 1. Pattern matrix of rotated factor loadings.

Item	Content	Factor		
		1	2	3
13	Generally I am a good critical thinker	.83		
14	I do well in assessments that ask for critical evaluation	.72		
8	I can express my critical thinking well in my written work	.68		
19	I have the ability to judge the value of new information or evidence presented to me	.68		
15	I think critically while working on my assignments	.68		
20	I can evaluate the arguments of others well	.67		
17	I know how to approach complex issues in a variety of ways	.66		
22	I am good at weighing up both sides of an argument	.65		
23	I can identify analogies between theories	.63		
27	I think critically in lectures	.62		
26	I can rephrase the arguments of others in my own words easily	.60		
24	When designing experiments I can readily eliminate extraneous variables	.60		
25	I think critically while reading	.57		
2	I have a well-defined goal in mind when I am critical	.55		
1	I can detect the use of inappropriate emotional language in scientific arguments	.54		
3	I can identify the structure of arguments without being distracted by their content	.53		
11	I have a focused and systematic way of thinking	.51		
16	All my lecturers expect me to think critically		.70	
5	Critical thinking is essential in higher education		.70	

18	I will get higher grades if I think critically	.67	
9	You cannot get a good degree without good critical thinking skills	.62	
4	Critically thinking is particularly important in psychology	.59	
7	Critical thinking develops as you progress through your degree	.54	
10	I prefer to do things where there is a quick answer		.54
6	When there is a very strong relationship between two variables we can claim that one causes the other		.54
12	All relevant information should be presented in lecture slides		.52
21	Critical thinking is when you describe what is wrong with something		.47

Note: Factor loadings lower than .45 are not shown.

Table 2. Mean Item Scores of Sub-scales and Means of Validation Measures.

	Mean	Standard Deviation	Min-to-Max	Skewness	Kurtosis
CriTT					
Factor 1: Confidence in Critical Thinking	6.75	(1.27)	1.29 - 9.82	-.654	1.58
Factor 2: Valuing Critical Thinking	8.33	(1.11)	5.33 – 10	-.672	-0.04
Factor 3: Misconceptions	5.75	(1.66)	1.75 – 9.25	-.391	-0.53
Cognitive Reflection Test	0.80	(1.07)	0 - 3	.937	-.583
Argument Evaluation Test					
Belief driven responding	.037	(0.21)	-.604 to .503	-.392	.231
Argument driven responding	.184	(0.31)	-.605 to .901	-.081	-.783
Grade Point Average	14.4	(2.26)	7.63 – 20.0	-.212	.463

Table 3. Pearson's Correlations Matrix of Factors and Argument and Belief driven responses to the Argument Evaluation Test and the CRT

	Valuing Critical Thinking	Misconceptions	Cognitive Reflection	Belief driven responding	Argument driven responding	Grade point Average
Confidence in Critical Thinking	.169	.004	-.046	-.200*	.122	.132
Valuing Critical Thinking		.012	-.100	-.249**	.222*	.234**
Misconceptions			-.097	.080	-.237**	-.184*
Cognitive Reflection				-.125	.240**	.261**
Belief driven responding					-.374**	-.201
Argument driven responding						.155

*p<.05, **p<.01

Table 4. Regression Analysis of CriTT Factors, CRT and AET

Model/Predictors	Regression Statistics
Block 1	R^2=.083, R^2_{adj}=.075, F(1, 111)= 10.02, p=.002
CRT	β= .288, p=.002, B=.576, p= .002
Block 2	R^2=.192, R^2_{adj}=.163, F(4, 108)= 6.44, p<.001
CRT	β = .274, B= .548, p=.002
Confidence in Critical Thinking	β = .157, B= .267, p= .083
Valuing Critical Thinking	β= .178, B= .341, p= .049
Misconceptions	β= -.197, B= -.260 p=.026