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Thinking about critical thinking: An industry perspective

Alastair Owen Pearl, Gerry M. Rayner, Ian Larson and Laurence Orlando
Monash University, Australia

Abstract
There has been a drive towards enhancing the critical thinking (CT) skills development of students in the science, technology, engineering and mathematics (STEM) disciplines, both in Australia and internationally. One debate among CT theorists centres on whether CT comprises a set of generalizable skills or is content- and context-dependent. While previous studies have considered CT skills development and its assessment in pharmacy courses, there appears to have been limited scholarly research within the pharmaceutical sciences discipline. In seeking to address this, it is vital to understand how companies conceptualize CT and its use by Bachelor of Pharmaceutical Sciences graduates. This research identifies five major categories used to conceptualize CT in the companies interviewed: being systematic, having strong business sense, considering multiple solutions, considering implications and identifying problems and potential solutions. The study finds that, while these skills are dependent on the business context, they may be generalizable across a range of industries.

Keywords
Critical thinking, employability, industry, stakeholder groups, STEM education

In recent years, critical thinking (CT) has increasingly become an in-demand trait for graduates of science, technology, engineering and mathematics (STEM) disciplines, both locally in Australia and internationally (Flores et al., 2012; Maxwell et al., 2010; Oliver et al., 2010; Osmani et al., 2017; Prinsley and Baranyai, 2015). Recent studies have reported that students (Canadian University Survey Consortium, 2017) and some industries (ABS, 2006, cited in Norton, 2016) view a university education as a means to secure more rewarding and highly paid employment. Previous research has also shown a correlation between a formal education and the development of reasoning skills (Ding, 2017), often through participation in experiential programmes (Hannon et al., 2004). The development of such reasoning skills feeds back into content learning (Kuhn et al., 2000; Lawson, 2004). Moreover, CT is considered as fundamentally important for fully engaged citizens in a modern world (Halpern, 2002; Ten Dam and Volman, 2004). Ten Dam and Volman (2004) argue in favour of a 'social constructivist' approach in defining CT as enabling a greater quality of participation in society. They consider CT in the context of '[participating] critically in the communities and social practices to which a person belongs' (Ten Dam and Volman, 2004: 359). To complement this conceptualization of CT, the empirical research below considers the conceptualization of CT in the context of the workplace.

Conceptualizing CT

CT is seen as a higher level of thinking, more than just thought (Ennis, 2015). Among modern conceptions, it has been considered as a 'purposeful act' (Halpern, 1998) of 'reasonable and reflective thinking' (Ennis, 1993) in the form of a series of actions that a critical thinker undertakes. Facione (1990) outlines one such approach in his seminal publication *The Delphi Report*. By way of consensus, he brings together many perspectives to define CT as a set of actions a critical thinker undertakes, such as 'analysis', 'evaluation' and 'inference'. He further expands this idea by considering a person's disposition towards using CT skills. That is to say, it is not sufficient that we know how

Corresponding author:
Ian Larson, Drug Delivery, Disposition and Dynamics, Monash Institute of Pharmaceutical Science, Monash University, 381 Royal Parade, Melbourne, VIC 3052, Australia.
Email: ian.larson@monash.edu

to think critically, but that we are inclined to think critically when appropriate. Paul and Elder (2008) also suggest the inclusion of 'intellectual criteria' or standards that define how well these actions should be conducted in order for the actor to be considered a good critical thinker (e.g. logic, clarity and precision).

This research integrates the CT competencies (cognitive skills and dispositions) of Facione (1990) and the intellectual criteria of Paul and Elder (2008).

Context specificity and the transferability of CT

There is an ongoing debate about the ability of a learner to take CT competencies developed in the classroom and apply (transfer) them spontaneously in novel situations (Ennis, 1989; McPeck, 1990; Perkins and Salomon, 1989), and even about the degree to which this transfer of skills is currently being done (Davies, 2016). The discussion concerning transferability is intimately linked with the debate concerning the generalizability of CT skills – in that, without transferability, CT skills would not be generalizable outside a classroom setting. Halpern (1998) describes the goal of instruction in CT techniques as the ability to transfer these skills out of the classroom into 'real-world' settings. One way of addressing this may be through a constructivist approach in which knowledge is constructed through interaction with phenomena (Watts et al., 1997). In this case, the phenomenon to which students would need to be exposed would be in-context CT. To this end, CT is an ideal candidate for a constructivist approach in that 'critical constructivism' concerns itself with 'complex multilayered circumstances which entail, for instance, awkward or unresolvable issues which cannot be tackled easily' (Watts et al., 1997: 311). The complexity of these 'circumstances' and 'issues' aligns with the types of CT problems envisaged by social constructivists like Ten Dam and Volman (2004), among others.

The inability of students to recognize the appropriateness of their CT skills in novel situations (Bransford et al., 1999; Halpern, 1998) may limit transferability. One way an improvement in CT transfer might be achieved is through the use of authentic scenarios in teaching and assessment that reflect a situation in which the students are required to utilize their CT skills. Bransford et al. (1999) discuss such ideas by describing how students may be presented with a specific task in one specific context before being presented with another, similar context. This approach, they posit, will enhance students' ability to identify which general principles can be transferred. One way this concept may be applied is through a valid or realistic representation of the situation in which the student would be expected to use the desired skill. The use of authentic tasks, particularly in assessment, is supported by the work of Lund (1997), who describes how well-developed authentic assessments can induce higher-order thinking (including CT). She describes 'well-developed authentic assessments' as including, among other things, (1) meaningful tasks that simulate real-world tasks, (2) the aim of eliciting higher-level thinking rather than rote memorization, (3) clearly articulated assessment criteria, (4) formative rather than summative assessment and (5) assessment of the thought process as well as the end products. Lund argues that through such an approach, the assessor is able to detect, for example, 'faulty logic . . . [that] could mean wrong decisions in future . . . ' (Lund, 1997: 27). One study has indicated a moderate improvement in CT skills through teaching that uses authentic tasks (Colletti, 2011), but what is not clear in this instance is the degree to which these developed CT skills were transferable.

Other promising methods of addressing the issue of transferability have been reported. In one such example, detailed by Helsdingen et al. (2011: 384), participants were assigned to either regular or random schedules for practising on 'complex judgement tasks'. These schedules were supplemented with post-practice CT prompts which led to substantial performance gains on these 'complex tasks'. The specific teaching of CT also appears to have had a beneficial effect on economics students' reasoning skills (Heijltjes et al., 2014).

Discipline-specific CT

Many disciplines have considered CT (or an allied concept) as a key employability marker. Taking engineering as an example, van der Wal et al. (2017) look into the 'techno-mathematical literacies' required of modern engineers. While not explicitly articulating 'critical thinking', they do discuss 'data literacy' and a 'sense of error' as key skills. Most tellingly, they describe these literacies as abilities to 'analyse', 'interpret', 'draw conclusions' and 'check and verify'. This conceptualization is very much in the language used by Facione (1990) and later by Paul and Elder (2008). Other disciplines have developed a context-specific test of CT ability for measuring the degree to which courses instil CT in students. For example, in the nursing field, the Health Sciences Reasoning Test (HSRT) has been used extensively to assess CT skills in undergraduate courses (Hunter et al., 2014). The HSRT focuses on those skills outlined by Facione (1990) (interpretation, analysis, evaluation, inference, explanation, self-regulation) in 'clinical and professional contexts' (Insight Assessment, 2016). Interestingly, the HSRT has also been trialled as a pre-admission diagnostic test for pharmacy (Kelsch and Friesner, 2014). Although there are some similarities between a pharmacy course and the pharmaceutical sciences, it would appear that this test was primarily intended to address the CT skills used when handling patients (pharmacy practice) rather than those used in drug discovery and formulation (pharmaceutical sciences). This test thus appears to be

industry-aligned for pharmacy but not for the pharmaceutical sciences. Again, there does not appear to be a specific test for pharmaceutical sciences; no test addresses industry-aligned CT as it would be undertaken in industries that employ graduates of pharmaceutical sciences courses. This indicates a potential avenue for the exploration, development and evaluation of such a test.

CT in the pharmaceutical sciences context

Graduates of our undergraduate pharmaceutical sciences course typically go on to employment in pharmaceutical and consumer goods companies. A direct approach to understanding how CT is conceptualized by these industries is to ask them and then look for those concepts that can be considered as CT by comparing them against currently accepted understandings of CT. While studies of CT skills development have been conducted in many educational areas, including pharmacy (Gleason et al., 2013; Peeters and Boddu, 2016), a search of the literature has not uncovered any studies to date that look at CT competencies in undergraduate pharmaceutical sciences students. The need to address this gap in the literature is additionally supported by work that found benefit for each stakeholder group in linking industry experience with the educational setting, such as benefitting industry through access to strongly developed graduates (Brunton and Coll, 2005).

Study aims

This research aims to probe how the concept of CT is understood by employers who engage graduates from the Bachelor of Pharmaceutical Sciences. It is our intention to develop a better understanding of the utility of CT in the workplace from the employers' perspective. Specifically, this study addresses the disconnect in CT conceptualization between the tertiary sector and the pharmaceutical and consumer goods industries in Australia. The findings may inform curricula development with regard to CT and therefore may be specifically useful for educators and students in the pharmaceutical sciences and related fields in developing CT at an undergraduate level.

The research used semi-structured interviews, as detailed below. Specific companies were selected based on their pre-existing relationship with the Monash Faculty of Pharmacy and Pharmaceutical Sciences (MPPS), either through the taking of students on work placements or as employers of MPPS graduates. These companies operate research and development (R&D) or production facilities within the greater Melbourne area and operate in local, national or international markets.

The research set out to investigate primarily how the companies conceptualize CT, and also to consider whether they expect universities to be the sole source of students' CT development, and what methods they use to assess CT in graduates during the hiring process.

This article focuses primarily on the first of the above research objectives and will follow the investigation, starting with a qualitative analysis of the transcribed interviews and identification of key emergent themes. Next, these themes will be qualitatively analysed to determine the degree to which they were discussed and how that reflects their relative importance. The remaining two research aims will be considered separately in a brief qualitative discussion, highlighting key findings and implications for curriculum design and teaching.

Study design and implementation

Measures

In addressing the research aims, industry representatives were invited to take part in a semi-structured interview so that we could gauge their perspectives on CT. This method of data collection was chosen to allow respondents to develop ideas freely while staying within the structure and guidance of a set of questions (Cox and Cox, 2008). The interviews included open-ended questions concerning industry's expectations of graduates and its skills requirements, its understandings of problem-solving and CT-type skills in the workplace and its opinion on the skills and intellectual criteria of Facione (1990) and Paul and Elder (2008).

The structured content of the interview was revised several times based on feedback from colleagues who had previously used interviews as a data collection method for canvassing opinions from industry. This feedback focused on the removal of redundant items and a redesign of potentially leading questions. Additionally, our approach to the design and piloting of the semi-structured interview questions followed that outlined by Turner (2010: 754) for what he describes as 'standardized open-ended interviews'. The approach he outlines includes the deliberate choice of open-ended questions with neutral and clear wording.

Semi-structured interview questions. During the interviews, it was important to clarify which graduate jobs were being discussed. The first question listed below acted as the clarifying question, while the other questions were relevant to answering the objectives of this study:

1. What roles do your graduate employees typically undertake in their first year of employment?
2. Can you explain what exactly you mean when you say CT?
3. How would you describe CT, in relation to day-to-day work for a graduate in your company? What sort of problems do they have to solve?

4. How do you evaluate or know if CT skills are good/lacking for a graduate on the job?
5. Ideally, in your opinion, when should CT skills be taught?

In all cases, participation was voluntary, and the interviews were conducted during business hours at the workplace of the respondents. Respondents consented to being audio-recorded so that a verbatim transcript could be produced. The institutional human research ethics committee, MUHREC, granted ethics approval for the study.

Participants

Interviews were conducted with 38 respondents from 21 companies. Of the respondents, 37 were technical managers or direct supervisors of graduates, and two were human resources staff (with one acting in both capacities). The 21 companies were classified based on their primary business (e.g. personal care products, analytical services) or the departments that the respondents represented within a larger company (e.g. R&D). In each case, no company was classified in more than one category and the classifications were as follows: cosmetics/cosmeceuticals R&D ($n = 4$), drugs and vitamins R&D and production ($n = 4$), industrial chemicals production ($n = 4$), personal care products ($n = 3$), analytical services ($n = 2$), food/food additives R&D/quality control ($n = 3$) and clinical trials ($n = 1$).

Analysis

How companies conceptualize CT. To address the question of how companies conceptualize CT, interview transcripts were coded and analysed in order to identify emergent themes, which could then be grouped into broad categories. To this end, interview questions 2, 3 and 4 (as listed above) were analysed and categorized using the process outlined below. Originally, question 2 was intended to provide case examples of CT use by graduates. However, the respondents tended to provide vague or general answers rather than specific examples. Therefore, question 2 was analysed only alongside questions 3 and 4.

As noted above, verbatim transcripts of each interview were produced. Due to the free-flowing nature of the interviews, in many instances, the respondent would begin a response to one question and then inadvertently answer a subsequent question or provide further detail on previous question. This tendency was addressed by remapping responses to the relevant questions.

Analysis of the data was based on the 'process of inductive coding' described by Thomas (2006). This involves (a) preparing the raw data, (b) close reading of the text to become familiar with general themes, (c) the creation of themes, (d) making allowance for overlapping coding and uncoded text and (e) revision and refinement of the theme groupings. Steps (a) and (b) were conducted during the transcription process using standard word-processing software. The transcripts were then cut into individual sentences (utterances) and imported into a spreadsheet editor for categorization. This process allowed the industry discussion to be grouped initially into themes which were then grouped into broad categories.

Initially, each fragment of speech (hereafter 'utterance') was compared with the CT skills of Facione (1990) (i.e. analyse, evaluate, interpret, conclude, explain, self-regulate) and the intellectual criteria of Paul and Elder (2008) (i.e. accuracy, precision, relevance, significance, breadth, depth, clarity, logic, fairness). Utterances were sorted under each of these CT skills or intellectual criteria when the content of the statement was related to the definitions provided by the indicated literature. When sorting each utterance, it was important that the action being described could be directly attributed to the action or behaviour that a *graduate employee* would exhibit in the workplace. This excluded general commentary or, in some cases, the actions that a more experienced staff member would be expected to exhibit.

Theme validation and groupings. A secondary analysis and thematic identification process then occurred. Two education-focused researchers were each randomly assigned 25% of the industry utterances and asked to identify additional emergent themes. Finally, all utterances were classified under the full list of emergent themes, where possible. A further consideration of unclassified utterances was undertaken to determine whether any further themes needed to be created. All the final themes were grouped into the following broad categories: *actions*, *traits*, *good business sense*, *problem-solving approach* and *employability outcomes*. The full set of themes indicates the broad category, a brief description of the theme and an illustrative example from the transcripts (Table 1). Themes were analysed quantitatively both at the question level and looking at overall transcripts. As some interviews involved multiple respondents from the same company, the quantitative analyses were conducted on a *per company* basis. For each question, the percentage of respondents that discussed each theme at least once was calculated. In some instances no respondents from a company discussed certain themes, in which case the total number of companies that discussed that theme was appropriately reduced. As discussed below, the top five most expressed themes were then selected for further consideration.

With a final set of themes determined, two industry representatives were interviewed again to determine whether our interpretation of the selected themes was a fair representation of some of the utterances made. These two interviewees reviewed their own utterances that were classified into the top five themes, as well as a random 10% of similarly classified utterances from other respondents. This

Table 1. Industry interview: emergent themes, descriptions and explicatory examples.

Theme	Description	Example
Actions		
Break down the problem	To take a problem and determine the smaller aspects or problems to be solved	'"Can I get down to the very basic question, basic building blocks that put my project together?" From this I can build up'.
Ask the right questions	To ask probing, relevant questions to gain information	'Ask for help and learn from experienced people around them to get a better output than doing it on their own'.
Collaborate	Teamwork; workshopping solutions	'How do we find the solution? From when I see a critical thinker would be; let me understand the problem really well, what is the scale of the problem, is this something I can do on my own or do I need help from others?'
Consider implications	An awareness and understanding of the effects of one's decision or recommendations	'From my perspective a strong critical thinker will think about the endpoint; how will we solve the problem but not introduce more problems as part of it'.
Create	The act of doing/collecting/creating after having arrived at a conclusion	'You have the start of it which is "let's plan, let's think about everything." You have the end of it which is the conclusion. [. . .] But you don't have a middle section where you actually do the stuff'.
Make observations	Collecting data; making key observations	'I think that is probably the key because going on from the observation point of view, making those key observations and then understanding and for next steps what it means'.
Traits		
Attention to detail	Being thorough in collecting data or problem-solving	'When you go back and look at it you find that the methodology or the way they went about flushing out the root cause was not very thorough or comprehensive'.
Attitude	Personal traits that guide professionalism and problem-solving	'There's definitely been examples where people who aren't good at critical thinking say, "I just have no idea, I can't make any more of these, there's nothing else I can do" and pretty much give up'.
Initiative	To extend oneself and/or follow-up one's actions	'Demonstration of ability to go above what is asked and ask questions to understand concepts'.
Innovation/creativity	Lateral thinking; developing novel concepts or approaches	'I think creativity should definitely be in there, because I don't think that should be ruled out from science'.
Good business sense		
Business sense	An awareness of the constraints of working in the business context in relation to time, resources and so on	'Whilst we would weigh out the risks and benefits and understand that the customer has to get this product on the market in the next period of time and at a certain cost'.
Independence	The ability to work without guidance with regard to self-learning or problem-solving	'And to me that's the value of having critical thinking embedded in an employee is that they can make decisions themselves without the need for guidance'.
Problem-solving approach		
Common language	The use or awareness of precise terms when discussing problem-solving and its approaches	'"What is critical thinking?" Well we haven't been able to define critical thinking but every time this pops up you are doing it without thinking'.
Does not have to be the 'correct solution'	Undertaking the process of arriving at a solution even if that solution is not eventually selected	'At the graduate level, if they can provide a solution, it doesn't necessarily be the right one, that's the first step for us'.
Multiple solutions	Providing multiple viable recommendations/ solutions	'Not only thinking about possible solutions but exploring several and then prioritizing the one with the biggest chance'.
Systematicity	A disciplined, orderly approach to the problem-solving process	'[. . .] our pain lays in this space. Sometimes we just don't know that is something that we need to refer to because our processes here just haven't defined that'.

(continued)

Table 1. (continued)

Theme	Description	Example
Transferability	Adapting knowledge and a problem-solving approach to new situations	'Someone who is able to think critically, you can grab that person and put them in a situation and they should be able to apply that same skill regardless of what topic you are talking about'.
Employability outcomes		
Affects employability	A lack of CT may impact on a graduate's chances of getting a job or being successful in that job	'Maybe then I don't select them if they don't have a particularly strong critical thinking/problem-solving approach. Maybe less likely to select them, to come through the process. We look for that skill'.
Cultural/job fit	That the graduate employee is a good match for the current team and job requirements	'If you can't get along with our team, we won't hire you or you won't last here'.
A degree is sufficient	Having a relevant degree is more important than one's GPA	'Whether it is 51% or a 99% you still have a degree. Everything above the pass line is forgotten in the real world because it comes down to that key criteria'.
Desire not just academic skills	During the hiring process, non-academic skills are highly valued	'I think it shows that if they've achieved good results while doing other things, not just 100% focused on the study'.
Prior experience	Relevant and indirect work experiences are valued	'Another has worked at Crown [a casino] so they've dealt with drunk people and people yelling at them and difficult situations'.

Note: CT: critical thinking; GPA: grade-point average.

validation exercise yielded no changes to the themes or classification.

When to teach CT and methods to assess CT during recruitment. The second research aim was to assess perceptions of when it was appropriate to teach CT to students. This analysis involved a quantitative examination of the proportions of companies that wanted CT to be taught at university, in the workplace or both. The third research aim was to investigate instances when companies discussed the assessment of CT skills during the hiring process. Due to the small number of respondents, the analysis of both these aims is limited; however, exploratory and explicatory examples are provided.

Results and discussion

CT in these workplaces

Our first concern was to clarify the types of jobs that graduates from our pharmaceutical sciences course were doing and the general nature of the CT skills they were expected to employ. We were aware of previous graduates who had been employed in roles that were not the primary focus of the course; for example, sales and marketing, tertiary level laboratory demonstrating and finance. For the purpose of this research, we wanted to focus on those jobs that were directly related to the course material. In practice, this means laboratory-based jobs in a research, analytical or quality assurance role. In addition to these typical roles, we included input from a company that conducts clinical trials as this activity also forms a component of our course.

The responses regarding the type of job were categorized as follows: QC/QA ($n = 15$); formulation/product development ($n = 11$); administrative/technology transfer ($n = 2$); no response ($n = 2$), where the counts indicate the number of companies that mentioned these work areas as typical for a recent graduate of our course. Only three companies did not mention either QA/QC or formulation/product development as typical graduate jobs (two of these gave no response and the third, whose work is mainly administrative, conducts clinical trials).

Defining and understanding CT

For ease of use, a subset of the top themes was selected for further consideration. To this end, the researchers selected the top five themes as listed in Table 2. In making this selection, only those themes that were discussed by at least two-thirds of the companies ($n \geq 15$) were considered. They were also selected because, in the researchers' opinion, they represented a manageable number of distinct areas that higher education teachers and designers could use in curriculum development. Table 2 shows the percentages of companies that were recorded as having at least one utterance in the listed themes.

Although respondents identified these emergent themes as being representative of CT, to ensure that they were in fact representative they had to be compared with accepted definitions of CT. Three such definitions are Halpern's (1998: 450) description of CT as a 'purposeful, reasoned, goal-directed' act, Ennis's (1993: 180) understanding of it as 'reasonable and reflective thinking' and Facione's (1990: 2) conception of it as 'purposeful, self-regulatory

Table 2. Identified top themes, definition and percentage response to interview questions about defining and understanding CT in the company context.

Theme	Definition	Responding companies
Systematicity	A disciplined, orderly approach to the problem-solving process	100%
Business sense	An awareness of the constraints of working in the business context in relation to time, resources and so on	86.4%
Multiple solutions	Providing multiple viable recommendations and solutions	72.7%
Consideration of implications	An awareness and understanding of the effects of one's decisions or recommendations	68.2%
Identification/ awareness	To identify issues or problems and determine their component parts, and to identify the conceptual relationships of those parts to each other and to the whole	68.2%

Note: CT: critical thinking.

judgment'. Table 3 indicates how the identified themes relate to these definitions.

These themes obviously do not cover the gamut of CT as defined in the above three studies. However, for the purposes of this research, we only required that each theme that was compatible with the above definitions, and could then be regarded as illustrative of CT. One standout exception that is not captured by our industry-aligned CT concepts is the notion of *self-reflection* or *self-regulation*, which appears in various guises in all three of the studies we used for comparison. While the idea of self-reflection was not raised in the industry interviews, it may be worthwhile later to consider how it might be incorporated into our five industry-aligned CT themes/concepts.

More interestingly, the pre-existing concepts posited by Facione (CT actions) and Paul and Elder (CT criteria) were not addressed as extensively as these emergent themes. Specifically, when queried about the nature of CT (interview questions 3.1 and 3.2 – 'Are these [CT] skills important in your company?' and 'Can you explain what exactly you mean when you say [CT]?'), the most discussed pre-existing CT concept was *conclude* (40.9%, $n = 9$) (present in Facione, 1990). The highest CT criteria were *breadth* and *depth* (both 36.4%, $n = 8$) (present in Paul and Elder, 2008). The majority of companies discussed *systematicity* (81.8%, $n = 18$) and *business sense* (63.6%, $n = 14$). These suggest a focus on CT as a means of solving specific, business-related problems. Pertinently, they appear to recognize problem-solving as within the context of the business setting, rather than related to loftier goals such as benefitting the wider society, as per Facione's (1990: 2) definition of CT as those 'CT skills [. . .] which are the basis of a rational and democratic society'. This would appear to be a more holistic approach to CT than that espoused in the CT literature.

A similar study has been undertaken in the field of chemistry (Danczak et al., 2017). In the initial part of this research, employers were contacted online to answer the question, 'What does the term "critical thinking" mean to you?' The authors found that *problem-solving* and *identification of opportunities/problems* were the top two categories in employers' responses (over 44% and 35%, respectively). Danczak et al. (2017: 425) describe problem-solving broadly as dealing with a 'problem and/or something that needs to be resolved'. This orientation of CT towards problem-solving is also evident in our research, where many of the top themes when defining CT related specifically to the solving of a problem or issue (*systematicity*, *multiple solutions* and *considering implications*, for example). Similarly, the *identification of opportunities/problems* as identified by Danczak et al. may be reflected in categories that emerged in our research (*consider implications* and *identify*). There is commonality in the findings of Danczak et al. and this research in that problem-solving and CT in industry appear to be focused more on the product of the problem-solving and less on the procedures or conceptualizations of CT as posed by Facione, Ennis and others. In these industries, then, CT is understood primarily as a problem-solving tool. Responding companies from a range of industries identified CT as a systematic process, solving problems in the business context, identifying problems and the required information, providing multiple potential solutions and being aware of the consequences and implications of those solutions. These responses are interestingly comparable to those found by Papadopoulos (2010) when looking at business graduates in the same geographical area as that in which our study was conducted. Papadopoulos found that, while technical skills were important, it was incumbent on students to 'take a more holistic approach to education, in which co-curricular and personal life experiences are as important as coursework'.

When to teach CT and implications for curricula

Responses were qualitatively analysed to determine whether industry representatives felt that CT should be developed at university or on-the-job and how this might influence the perceived employability of graduates. From the responses, 95.5% ($n = 21$) of companies indicated that CT should be developed at university, with a smaller proportion discussing development of CT in the

Table 3. Comparing top themes with published understandings of the nature of CT.

Theme	Halpern (1998)	Ennis (1993)	Facione (1990)
Systematicity	'habitual use of plans'; 'willingness to abandon non-productive strategies'	'plan experiments . . . '	'orderliness in working with complexity'
Business sense	'an awareness of the social realities that need to be overcome'	'define terms in a way appropriate for the context'	'to assess the contextual relevance of [. . .] information, principles [. . .]'
Multiple solutions	'generating and selecting alternatives and judging among them'	'conceiving of alternatives'	'formulate multiple alternatives for resolving a problem'
Consideration of implications	'evaluating the outcomes of their thought processes – how good a decision is or how well a problem is solved'	'draw conclusions when warranted, but with caution'	'educe the consequences . . . '
Identification/ awareness	No clear mention	'identify conclusions, reasons, and assumptions'	'recognize a problem and define its character'

Note: CT: critical thinking.

workplace (77.3%, $n = 17$) – most of these companies discussed the development of CT both at university and in the workplace. A much smaller number discussed the teaching of CT exclusively either at university (22.7%, $n = 5$) or in the workplace (4.5%, $n = 1$). Explicatory responses are given below.

In considering CT during the hiring process, most respondents discussed generally how they used behavioural-style questions (81.0%, $n = 17$) that might or might not elicit a response relating to CT. Many (61.9%, $n = 13$) were also quick to indicate that work experience, or other prior experience, was highly regarded during the hiring process. However, these responses were not directly addressing or discussing CT skills.

The general consensus among respondents was that CT should first be taught at university and then refined in the workplace. The following response exemplified this position:

> It would be good to have some basic critical thinking abilities before you enter the workplace but I do find that the experience [*sic*] that you get in the workplace do add on to critical thinking.

This quotation is also indicative of the overlap of discussion about the teaching of CT at university and development in the workplace. Several respondents detailed specifically how CT could be taught at university such that it would provide an initial understanding or a common language. This understanding could then be developed by the company in its particular context. Interestingly, this viewpoint does reflect discussion in the literature about generalizable CT skills and context-specific CT skills development. What was regrettably not discussed in this instance was whether a teaching model similar to Ennis's mixed approach to teaching CT would address both the generalizable skills and context-specific skills while the student was within the university system.

Several respondents discussed how CT might best be taught, with some opining that it should be taught within a pre-existing unit of study:

> I wouldn't teach it separately, it would be too fake, it wouldn't be real enough [. . .] Don't teach it specifically, just teach it within the curriculum.
>
> I think you can still be clear with the outcome [of a laboratory practical] and what resources you can put towards it but you can tell them less about how they should go about it and let them develop that.

Following the observation that CT should be developed at university and then refined in the workplace, there are some clear implications for higher education providers and curriculum designers. Holmes et al. (2015) argue for the development of CT skills in a scaffolded manner across general sciences education as a way to address a perceived lack of opportunities to develop these skills. Specifically, they argue for explicit CT education that requires students both to learn and to actively apply CT skills in their context. This aligns with the view of Lund (1997) concerning the use of well-developed authentic assessments to induce higher-order thinking. Holmes et al. (2015) allude to the notion of gradually developing these skills over the duration of the undergraduate course (i.e. skills scaffolding). If other degree disciplines were to use a similar approach to understanding industries' skill requirements, they would need to engage with those industries. The additional benefit here is the breaking down of obstacles between tertiary institutions and industry. Looking at the pharmaceutical industry, Paranhos and Hasenclever (2011: 402) noted that a major obstacle to further university–industry relationships was 'mistrust, distance and a lack of understanding between researchers and companies'. True engagement that

can then be seen to be acted upon is another clear way to develop that trust and understanding.

Effects on employability

Following this line of reasoning it is not surprising that some companies also considered the effect of poor CT ability on graduate employability:

> If you don't have the critical thinking part, at least the basics of it introduced at university, you might be at the risk of not getting a job.
>
> Maybe then I don't select them if they don't have a particularly strong critical thinking/problem-solving approach.

Extending this understanding of the development of CT in students, it became clear that CT is seen as a very desirable skill for a student to possess when they move into industry. What was not yet clear, however, was how companies might assess this skill during the recruitment process. It was then pertinent to ascertain whether CT development might lead to an improvement of the likelihood of a student becoming employed.

While much of the discussion on the assessment of skills during the recruitment process was not specific to CT, some observations emerged on assessing a student's CT ability through behavioural-style questions. For example:

> Either we ask for case studies where they used different thinking or some life experience where they had to come across some solution that was not mentioned in books.
>
> 'Give me an example of a project that you had control over'. And then we talk through bits like 'What happened when it went wrong?'

This lack of directed questioning on CT (or problem-solving, as many respondents preferred to term it) may result from an expectation or understanding that students do not have industry-based examples to draw on:

> Again we appreciate that they may not have all the . . . some of the questions around experience and they may not have the work experience yet.

However, some respondents discussed the use of CT skills in different (non-industry) contexts:

> From a personal perspective when I have interviewed people-it is tricky because sometimes students don't have the experience about 'Have you had any experience where you had a problem and what have you done to solve it?' Sometimes it could be in a retail environment.
>
> Some will think up good examples, and again this can be coming from their other activities.

Companies clearly articulated the desire for universities to undertake more in the way of teaching and developing CT skills. This was, curiously, coupled with the notion that these skills are not directly or explicitly assessed during the recruitment process, even though candidates' CT ability is indirectly probed through behavioural-style questions looking for examples of how they have handled problems they have encountered. While the use of CT to solve problems in industry was seen as the ideal (the most direct) expression of CT skills, companies were aware that recent graduates might not have the relevant experience and so were prepared to rely on other examples to demonstrate those skills. This may indicate an area in which students can be proactive by highlighting how they have demonstrated CT skills. Whether this should take the form of real-world or hypothetical (through an above-average score on a CT test, for example) demonstrations of these skills was not considered here. What is apparent, however, is employers' desire for graduate applicants to be aware of CT skills and to be able to talk about them:

> If students come into an interview and talk about these things, they will make everyone's ears prick up and think 'That's exactly what we need'. Because our pain lays in this space.

For the student, the benefits of developing demonstrable and transferable CT skills are clear. Being able to take the developed skills from the university and to express them either in a placement or during a job interview will increase a student's chances of becoming employed. Nevertheless, the ability to develop and practise CT skills is predicated on the curriculum designers and teachers in higher education providing sufficient and appropriate opportunities to do so.

Conclusion

This research suggests that those industries hiring our graduates understand CT to be a more goal-oriented and contextually-dependent skill, rather more holistic than current CT understandings. However, alignment of our emergent CT categories with the CT definitions espoused by proponents of the concept of generalizable CT does lend credence to the notion of generalizable industry-aligned CT skills. Furthermore, the emergent categories do not appear to be contextually limited to those companies or industries interviewed in this study. Alternatively, it may be that they interpret CT in a more unidimensional manner than do Facione (1990) and Paul and Elder (2008); that is, *systematic problem-solving* rather than *analysis*, *depth*, *breadth*, *logic* and so on. This disparity may indicate a need for greater, and/or more explicit, development of industry-aligned CT skills in students. In the light of our respondents' perspectives on teaching CT and on the advantages of CT in the hiring process, a focus on the awareness and

use of these skills may have a positive impact on graduate employability.

Study limitations and future research

This study represents an initial investigation into how CT is conceptualized by industries that employ graduates in the pharmaceutical sciences. We recognize the need for further study to address limitations in this research. Future directions may be grouped as (i) wider sampling, (ii) determining the implications for teaching CT at university level but at different stages in a degree programme and (iii) specific modes of assessing CT skills in the hiring process and the extent to which CT is implicit in other workplace performance indicators.

A larger sample of respondents from a more geographically diverse background would allow for a closer statistical analysis of emergent themes. This would enable the identification of differences in conceptualization based on location, company size and sub-industry type (e.g. fast-moving consumer goods compared to pharmaceuticals). Additionally, a wider sample would allow for analysis of those graduate jobs that are not the main focus of the course (such as sales and marketing). To provide a richer data set, case studies from employers could be sourced that illustrate how the identified categories are being used on a day-to-day basis by graduates.

Of interest to university educators, further research should consider the number and type of respondents who felt that CT should be taught as a separate subject at university, only taught in final-year studies or taught in an industry context using real-world examples.

In understanding how CT is assessed in the hiring process, further analysis could investigate (i) which of the industry-aligned CT concepts are most obviously being assessed using behavioural-style questions, and whether greater importance is attributed to any particular industry-aligned concept; and (ii) if industry-aligned CT concepts are being assessed during the hiring process, whether they are the same concepts highlighted in the understanding of CT in day-to-day activities. We believe that these further analyses will not detract from the findings presented in this article.

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ORCID iD

Alastair Owen Pearl https://orcid.org/0000-0002-7273-2863
Ian Larson https://orcid.org/0000-0001-7428-4307

References

Bransford J, Brown A and Cocking R (1999) *How People Learn: Brain Mind Experience and School*. Washington, DC: National Academy of Sciences.

Brunton M and Coll R (2005) Enhancing technology education by forming links with industry: a New Zealand case study. *International Journal of Science and Mathematics Education* 3(1): 141–166.

Canadian University Survey Consortium (2017) *2016 First-Year University Student Survey*. Available at: https://www.cusc-ccreu.ca/publications/CUSC_2016-First-Year-Report-EN.pdf (accessed 5 March 2018).

Colletti NE (2011) *The impact of completing authentic tasks on the development of critical thinking skills*. PhD Thesis, Capella University, Minnesota, USA.

Cox J and Cox K (2008) *Your Opinion Please!*, 2nd ed. Thousand Oaks, CA: Corwin Press.

Danczak S, Thompson C and Overton T (2017) 'What does the term critical thinking mean to you?' A qualitative analysis of chemistry undergraduate teaching staff and employers' views of critical thinking. *Chemistry Education Research and Practice* 18: 420–434.

Davies M (2016) *What is Critical Thinking? And do Universities Really Teach it?* Available at: https://the.conversation.com/what-is-critical-thinking-and-do-universities-really-teach-it-69046 (accessed 12 March 2108).

Ding L (2017) Progression trend of scientific reasoning from elementary school to university: a large-scale cross-grade survey among Chinese students. *International Journal of Science and Mathematics Education* 16: 1–20. DOI: 10.1007/s10763-017-9844-0

Ennis R (1989) Critical thinking and subject specificity: clarification and needed research. *Educational Researcher* 18(3): 4–10. Available at: https://www.jstor.org/stable/1174885 (accessed 15 April 2018).

Ennis R (1993) Critical thinking assessment. *Theory Into Practice* 32(3): 179–186.

Ennis R (2015) Critical thinking: a streamlined conception. In: Davies M and Barnett R (eds) *The Palgrave Handbook of Critical Thinking in Higher Education*. New York: Palgrave Macmillan, pp. 31–48.

Facione PA (1990) *Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction*. Millbrae: California Academic Press.

Flores K, Matkin G, Burbach M, et al. (2012) Deficient critical thinking skills among college graduates: implications for leadership. *Educational Philosophy and Theory* 44(2): 212–230.

Gleason BL, Gaebelein CJ, Grice GR, et al. (2013) Assessment of students' critical-thinking and problem-solving abilities across

a 6-year doctor of pharmacy program. *American Journal of Pharmaceutical Education* 77(8): 166–167.

Halpern DF (1998) Teaching critical thinking for transfer across domains: dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist* 53: 449–455.

Halpern DF (2002) *Thought and Knowledge: An Introduction to Critical Thinking*, 4th ed. New York: Taylor and Francis.

Hannon S, McBride H and Burns B (2004) Developing creative and critical thinking abilities in business graduates – the value of experiential learning techniques. *Industry and Higher Education* 18(2): 95–100.

Heijltjes A, van Gog T, Leppink J, et al. (2014) Improving critical thinking: effects of dispositions and instructions on economics students' reasoning skills. *Learning and Instruction* 29: 31–42.

Helsdingen A, van Gog T and van Merriënboer J (2011) The effects of practice schedule and critical thinking prompts on learning and transfer of a complex judgment task. *Journal of Educational Psychology* 103(2): 383–398.

Holmes N, Wieman C and Bonn D (2015) Teaching critical thinking. *Proceedings of the National Academy of Sciences* 112(36): 11199–11204.

Hunter S, Pitt V, Croce N, et al. (2014) Critical thinking skills of undergraduate nursing students: description and demographic predictors. *Nurse Education Today* 34(5): 809–814.

Insight Assessment (2016) *Health Sciences Reasoning Test (HSRT)*. Available at: https://www.insightassessment.com/Products/Products-Summary/Critical-Thinking-Skills-Tests/Health-Sciences-Reasoning-Test-HSRT (accessed 20 February 2018).

Kelsch MP and Friesner DL (2014) The health sciences reasoning test in the pharmacy admissions process. *American Journal of Pharmaceutical Education* 78(1): 9.

Kuhn D, Black J, Keselman A, et al. (2000) The development of cognitive skills to support inquiry learning. *Cognition and Instruction* 18(4): 495–523.

Lawson AE (2004) The nature and development of scientific reasoning. *International Journal of Science and Mathematics Education* 2(3): 307–338.

Lund J (1997) Authentic assessment: its development and applications. *Journal of Physical Education, Recreation and Dance* 68(7): 25–28.

Maxwell G, Scott B, Macfarlane C, et al. (2010) Employer as stakeholders in postgraduate employability skills development. *International Journal of Management Education* 8(2): 1–11.

McPeck J (1990) Critical thinking and subject specificity: a reply to Ennis. *Educational Researcher* 19(4): 10–12.

Norton A (2016) *Mapping Australian higher education 2016*. Available at: https://grattan.edu.au/wp-content/uploads/2016/08/875-Mapping-Australian-Higher-Education-2016pdf (accessed 13 March 2018).

Oliver B, Hunt L, Jones C, et al. (2010) The graduate employability indicators: capturing broader stakeholder perspectives on the achievement and importance of employability attributes. *Proceedings of the Australian Quality Forum 2010*. Available at: https://www.auqa.edu (accessed 12 March 2018).

Osmani M, Hindi N, Al-Esmail R, et al. (2017) Examining graduate skills in accounting and finance. *Industry and Higher Education* 31(5): 318–327.

Papadopoulos T (2010) Beyond discipline and technical knowledge: industry perspectives on the business curriculum. *Industry and Higher Education* 24(2): 109–114.

Paranhos J and Hasenclever L (2011) Is industry–university interaction promoting innovation in the Brazilian pharmaceutical industry? *Industry and Higher Education* 25(5): 397–407.

Paul R and Elder L (2008) *A Guide for Educators to Critical Thinking Competency Standards*. Dillon, MT: Foundation for Critical Thinking.

Peeters M and Boddu S (2016) Assessing development in critical thinking: one institution's experience. *Currents in Pharmacy Teaching and Learning* 8(3): 271–278.

Perkins D and Salomon G (1989) Are cognitive skills context-bound? *Educational Researcher* 18(1): 16–25.

Prinsley R and Baranyai K (2015) *STEM Skills in the Workforce: What do Employers Want?* Available at: https://www.chiefscientist.gov.au/2015/04/occasional-paper-stem-skills-in-the-workforce-what-do-employers-want/ (accessed 4 January 2018).

Ten Dam G and Volman M (2004) Critical thinking as a citizenship competence: teaching strategies. *Learning and Instruction* 14(4): 359–379.

Thomas D (2006) A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation* 27(2): 237–246.

Turner D (2010) Qualitative interview design: a practical guide for novice investigators. *The Qualitative Report* 15(3): 754–760.

van der Wal N, Bakker A and Drijvers P (2017) Which technomathematical literacies are essential for future engineers? *International Journal of Science and Mathematics Education* 15(Suppl 1): 87–104.

Watts M, Jofili Z and Bezerra R (1997) A case for critical constructivism and critical thinking in science education. *Research in Science Education* 27(2): 309–322.