Strategies for Maintaining Academic Integrity in First-Year Computing Courses

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ABSTRACT
Safeguarding academic integrity is an issue of concern to all computing academics due to high and rising levels of plagiarism and other cheating in computing courses. There have been many studies of the cheating and plagiarism practices of computing students and the factors that can influence these practices, and a variety of strategies for reducing cheating have been proposed. This national study of first-year computing programs provides insights into what strategies computing academics use to discourage or prevent their students from cheating. Having interviewed 30 academics from 25 universities we found 21 different types of strategy, which we classified into five themes: education; discouraging cheating; reducing the benefits of cheating; making cheating difficult; and empowerment. We also found that academics often employ strategies across all of these themes.

Keywords
CS1; assessment; academic integrity; cheating; plagiarism

1. INTRODUCTION
There is widespread concern about violations of academic integrity in university courses, with many reports of high levels of cheating in exams and in coursework. Furthermore, the incidence of these practices appears to be rising [2,12]. With the Internet facilitating access to resources and assistance, it is increasingly easy for students to find materials and even personal assistance with assessment tasks [7,9]. Problems arise when such resources or assistance are used inappropriately or without proper attribution.

Violation of academic integrity is a critical issue for universities to address. Cheating can damage the reputation of a course, an

institution, and a discipline. Not only does the cheating student miss out on an expected learning experience, but the cheating can also degrade the educational environment, ultimately affecting learning for all students [4].

Some studies have shown that violation of academic integrity is disproportionately high in computing courses [6,14], although there is some conjecture as to whether the reported higher levels are simply due to greater use of detection tools by computing academics [10]. Regardless, the levels of cheating in computing courses are certainly high [15].

This extensive national research project has provided the opportunity to gain insights into what computing academics do to discourage or prevent their students from cheating and plagiarising. The aim of this report is to identify and categorise the strategies used by computing academics to safeguard academic integrity in their introductory computing courses.

2. ACADEMIC INTEGRITY IN COMPUTING COURSES
Any strategy employed to safeguard academic integrity requires knowledge of student cheating practices. There is a corpus of research about this topic in regard to computing students, with research studies investigating what types of cheating computing students practice, why they cheat, and what would discourage them from cheating [6,16]. Over a range of practices the main influences on cheating in a couple of large studies were found to be time pressure and concerns about failing, while the main countering influences were students' desire to learn and to know what they have learnt [16,17].

Some computing courses have particular characteristics that can influence students' understanding of academic integrity and consequently their behaviour. In programming courses, the standard practice of code reuse can cause confusion about the appropriate use and attribution of code written by others [13]. At the same time, university-level information resources and policies about academic integrity typically focus on written prose and are usually not adequate to inform students about appropriate use and citation of others' code [19,21]. Likewise, many institutions mandate the use of text-based similarity detection tools, unaware that these are useless in the detection of program similarity. While there are many tools available for the detection of code similarity, most computing academics appear

not to use them [21]. Finally, although not specific to computing courses, the requirement for group work in many courses can cause issues with attribution of work and with students' understanding of the difference between collaboration and collusion [6,20,22]. If strategies to address cheating among computing students are to be effective, they should take these factors into account.

Safeguarding academic integrity entails reducing the incidence of cheating. A previous study of academic integrity in computing courses proposed that the process of addressing cheating could be considered from four perspectives: education, prevention, detection, and consequence [5]. Education and prevention are proposed as the key considerations for strategies to stop cheating from occurring, while detection and consequence focus more on dealing with cheating after it has occurred.

The literature reports many ideas for reducing cheating in computing courses. Some strategies have focused on educating students about what constitutes cheating, the problems associated with cheating, and possible consequences. These strategies take various forms, including information material, education programs, and educative tools. For example, Stepp and Simon [22] required their students to devise and then discuss scenarios describing inappropriate collaboration practices. Joy et al [8] describe a resource to assess computing students' understanding of plagiarism and to help the students learn how to avoid it.

Investigating the cheating phenomenon through student focus groups, Dick et al [5] concluded that students were in need of education about cheating and plagiarism. They proposed a comprehensive list of 12 characteristics for such an education program; however, the students in their study maintained that education on its own would not be effective. Simon et al [19] described different ways that academics in their study informed their students about academic integrity. An interesting response from some students in this study was that they received little appropriate instruction about academic integrity.

A number of strategies have focused on preventing cheating through various means ranging from reasoned discouragement to making cheating difficult. The strategies proposed by Dick et al [5] in their focus group study include individualised assignments, continuous assessment, monitored assessment, peer assessment, and interviewing students about their assignment work. Although interviews are typically intended to detect cheating, students saw them as being highly effective in reducing cheating. Student presentations were also seen as effective, although to a lesser extent. The study by Simon et al [19] found that academics commonly used a number of these strategies except for interviews and peer assessment.

Other strategies have focused on helping students not to cheat through building a strong and supportive culture of academic integrity. This approach is championed by McCabe [11], who reports success with honor codes in the US. Dick et al [5] point out that honor codes are not possible or appropriate in all contexts, but some of their proposed strategies take a similar approach. For example, they suggest that caring about students and ensuring a high level of student interaction in the classroom would reduce the level of cheating.

The deterrent effectiveness of detection and punishment remain unclear. Fraser [6] argues that high rates of detection and prosecution will deter cheats, and conversely that students are more likely to cheat if they believe cheating is commonplace. An empirical study by Bennett [1] found that punishment was a deterrent to major forms of plagiarism but not necessarily to minor forms. However, Sheard and Dick [16] found that fear of consequences did not appear to have any influence on the level of cheating.

These studies indicate that there are many effective strategies that can be used to safeguard academic integrity in the computing education environment. In our study we investigated what strategies are actually used by academics in their important role as the designers and providers of the learning environment and the assessment tasks. The findings reported in this paper give insights into the focus of the academics' attention in ensuring academic integrity in the assessment strategies that they employ.

3. RESEARCH APPROACH

This study draws upon data collected in 2014 for a report on teaching practices in first-year computing courses in Australia [18]. The purpose of the report was to document information about teaching practices and factors influencing the first-year experience of computing students in the Australian higher education context.

For the report we interviewed 30 academics from 25 universities, all of whom were involved in teaching and/or coordination of first-year computing courses. Participants were recruited mainly by contacting computing departments to identify the staff involved with delivery of first-year computing programs. The recorded telephone interviews, which ranged in length from 45 to 60 minutes, were all conducted by a single researcher.

The semi-structured interview script addressed six themes designed to investigate different aspects of the first-year experience: what we teach; where we teach; how we teach; how we assess; how we strengthen the learning environment; and how we support our students. The interview questions pertinent to the current analysis are:

- What types of assessment are used in first-year courses?

- How are the students educated about academic integrity in the context of computing courses?

- How much of the assessment is more or less guaranteed to be the work of the individual?

- For work not done in supervised conditions, what techniques are used to verify that the work is the student's own work?

The responses to the first interview question were analysed to give an overview of the forms of assessment used in first-year computing courses, as reported in section 4.1.

The responses to the other three questions were coded using a thematic analysis [3]. Each code represented a particular type of strategy that was used to reduce cheating in a first-year computing course. The data was coded by one of the authors, then the codes were reviewed by two other authors, discussed, and refined as appropriate. The types of strategy were organised into four themes and again discussed and refined. The themes and strategies found are reported in section 4.2.

4. FINDINGS

We begin with an overview of the types of assessment used in the introductory programming courses in this study, then report the strategies used by the academics to reduce the occurrence of cheating in their courses.

4.1 Forms of Assessment

Overall there was a mixture of invigilated and non-invigilated assessment. An end-of-semester written exam was the typical form of summative assessment in first-year computing courses. Most exams were weighted between 40% and 60% of the overall mark for the course, with 50% the most common weighting. The lowest weighting was 20% and the highest was 70% of the overall mark.

In combination with an end-of-semester exam there were a variety of other forms of assessment. The most common was assignment work, done individually or sometimes in a group. Often more than one assignment was set during the semester or the assignment was set in stages. Tests held during semester were another common form of assessment. These were either mid-semester tests worth 10% to 20% or a series of smaller tests, typically conducted online. Tasks performed in tutorial or lab classes were also often used as low-stakes assessment worth 1% to 2% for each task.

Less common forms of assessment mentioned were portfolio assessment, presentations, and submitted homework tasks. One interviewee gave students a mark if they visited the lecturer to ask a question. There were indications of a growing use of social media, such as blogs and wikis, for assessment tasks.

4.2 How Computing Academics Safeguard Academic Integrity

Computing academics employ many different strategies in their attempts to uphold academic integrity in their courses. The analysis found 21 different types of strategy which were organised into four overarching themes: *education* (raising awareness and understanding of what constitutes cheating and its consequences); *discouraging cheating*; *making cheating difficult*; *reducing the benefits gained from cheating;* and *empowerment* (supporting students and helping them understand the benefits of behaving with integrity). The themes and strategies are shown in **Table 1** and further explained in the following sections.

4.2.1 Education

A number of strategies used to safeguard academic integrity involve educating students about the acceptability of different practices in the use of resources and assistance. The aim is to help students understand what practices constitute cheating and plagiarism, and the consequences of engaging in these practices. Strategies classified as education involve instruction, provision of information resources, and using instructional tools.

The interviewees described different approaches to educating first year computing students about academic integrity, ranging from *"a little bit ad hoc" (I-11)* to *"academic integrity is in every session that I [teach]" (I-7).*

In more than half of the universities, academic integrity was taught by a central unit, either as a dedicated course or as part of a study skills course. In the other universities it was covered within individual courses. A few interviewees seemed to take a 'hands-off' approach, just pointing students to resources or

Table 1: Strategies to reduce cheating

Theme	Type of Strategy
Education	Instruction about academic integrity
	Information resources
	Instructional tools
Discouraging cheating	Heightening awareness of the consequences of cheating (e.g. punishment)
	Requiring students to commit to abide by academic integrity policies
	Observing students working
	Monitoring work
	Setting staged assignments
	Making work visible
	Requiring students to work in groups
	Oral presentations
	Interviewing students
	Making it too risky to cheat (e.g. detection)
Reducing the benefits of cheating	Low stakes assessment
	Setting hurdle assessments
	Verification of assignment work in exams
Making cheating difficult	Invigilating assessment
	Individualising assessment
Empowering students	Supporting students
	Building relationships with students
	Focusing on learning gained through doing the assessment tasks

relying on the university courses; however, most discussed and related academic integrity issues to their own courses.

[Academic integrity] is something that I discuss with them because the [course] that I do is generally one of the first they are likely to do. I talk about some of the specific traps that people could fall into; working together or ending up with someone's code and submitting that as your own and that sort of thing. So I discuss it specifically in the lecture as to what can happen and how they can protect themselves against getting into that situation. (I-12)

Instruction about academic integrity typically begins early, usually during orientation week or the first lecture.

I start off very early talking about what they can steal online and how they can do it. Basically, I say 'I'm happy with you finding code online as long as you tell me where you got it from'. As long as it's not the entire program. If you bought the program you won't get the marks. (I-5)

A particular concern in academic integrity is helping first-year students distinguish between acceptable collaboration and collusion:

Often in first year, because they are working together ... we have a chat with them about collaboration and when it's appropriate and when it's not. .... We tell them it's OK to work in collaboration in the sessions but when it comes to the practical we want them to work independently and we tell them what that means. (I-9)

Most interviewees mentioned providing links to university plagiarism policies in course websites and in documents such as course outlines and assignment specifications. Many universities have created online resources, including instructional tools, to inform students about academic integrity.

A few interviewees mentioned ploys to ensure that their students access these resources. For example, at one university students were expected to complete a quiz on academic integrity in their first year of study. This quiz is worth 5% of a student's grade. At another university academic integrity is taught with an online module that can also be used as a contract with the student.

A number of interviewees mentioned a combination of activities forming multifaceted and integrated approaches to educating students about academic integrity. For example:

> *Lecturers provide information and discuss (in class) academic integrity policies, why academic integrity is important and consequences of breaches, etc. There are a couple of sessions with the [special unit] leaders that are devoted to academic integrity. ... This is reinforced through the study desk. Forums are used to discuss academic integrity and what is acceptable. ... There is a link to library resources on academic integrity as well. (I-3)*

However, one interviewee suggested that the educational approaches are not entirely necessary:

> *... possibly more could be done ... but the majority of students who [cheat] are the ones who keep doing it time and time again. We don't get too many students who say they didn't understand that and honestly mean that. We do have a few issues with international students with things being a little bit different in their culture but for the majority of domestic students they learn that stuff in high school. (I-16)*

4.2.2 Discouraging cheating

Interviewees described a number of approaches they had used to discourage students from cheating. Ten different strategies were identified and most of these related to in-semester assignment work.

To heighten awareness of the consequences of cheating, some interviewees sent or posted reminder messages to their students. In one case a letter was sent from the head of the school:

> *...every semester the Head of School sends an email to all students saying there were X number of students found guilty of plagiarism this semester and you should all be taking this seriously. He gives feedback about what students have been caught plagiarising to show them that we're actually catching them and doing something about it. (I-13)*

A common practice is to require a commitment from students that they will abide by academic integrity policies:

> *... in the first introductory lecture we talk about academic integrity and then whenever they log in to the environment, first they have to read about this academic honesty policy and agree to those terms and conditions". (I-9)*

Alternatively, when submitting an assignment students make a declaration that the work is their own "*They sign their life away physically or electronically when they submit things.*" (I-1)

Taking a different approach, as a deterrent to cheating some interviewees mentioned observing their students working in class and actively monitoring their progress:

> *With the lab work generally most of that work is done in class so you have a fair idea based upon how they're progressing ... You also have the opportunity to ask them questions about 'what does that bit mean' or 'why did you do it this way'. If there's any question about whether the work is their own – sometimes someone will turn up at the start of the lab and has already done all the work – ... the tutor can ask them about it to get some reassurances about whether they understood it and therefore were likely to have done it themselves. It's not supervised in the same way as an exam but it's some kind of reassurance. (I-12)*

Some interviewees used staged assignment work, with marks allocated at specific checkpoints, to enable monitoring of progress. This strategy helped students avoid pressures to cheat by encouraging them to start their assignments early and giving them more time to seek legitimate help if needed.

Observation and monitoring of student work is also possible electronically with the use of social media. An added advantage is that a student's work is visible to other students, which discourages them from using work that is not their own.

> *... we get students to collaborate on assignments or content on a Wikipedia-style server that they can all edit simultaneously. That's been successful. .... Because it's online the students see an evolving project and can see the group members' work. As staff members we ... can see who's doing work and who's not. (I-12)*

There was no consensus about whether students should be required to work individually or permitted to work with others on their assignments. A number of interviewees required their students to work individually; however, one required students to work on their assignments in pairs as he considered "*... this makes it much less likely that they will seek outside help*" (I-14).

Another strategy was to interview students or require them to give presentations as part of the assessment process.

> *Interviews are quite popular in the programming type subjects ... You can ask them a few pointed questions about their motivation for the design they made, why they did it that way, and you can start to poke them a bit and say 'if we were to change this what would happen; if you wanted to do this feature how would you do it'. I've used the interview and they tend to be pretty good at picking up students who mightn't [have done] all their work (I-1)*

Although some interviewees saw interviewing as an effective strategy to discourage cheating, not many used it as it was seen as too time-consuming.

A common strategy to discourage cheating was to increase the risk of getting caught. A number of interviewees said that their use of similarity detection tools was a deterrent to plagiarism as the students were made fully aware that the tools would be used and they received the reports generated.

4.2.3 Reducing the benefits of cheating

A strategy used to deter cheating was to reduce the benefits gained from cheating. Several interviewees used low-stakes assessments, for example, in-semester tasks worth 1% to 2%, believing that students would not find it worthwhile to cheat for so few marks.

To reduce the chance of students passing entirely on other people's work, at many universities students are required to gain a minimum exam mark, typically 40% or 50%, to pass a course. That is, they reduce the benefit of cheating on one assessment item by establishing another item as a hurdle that must be cleared. A couple of interviewees observed that they used exams to verify that the students had done their own assignment work. One advised "*we kind of design the final exam to make sure that*

the students have done their work" (I-10). However, another mentioned his university's policy that *"exams are not to be for the purpose of ensuring that people haven't cheated"* (I-8).

4.2.4 Making cheating difficult

Moving beyond discouragement, a number of strategies were used to greatly reduce the opportunity to cheat.

Interviewees agreed that the incidence of cheating is greatly reduced in invigilated situations. As one interviewee noted, *"the only thing you can absolutely guarantee are the moderated parts, which are the exams"* (I-4). All universities had invigilated assessment in at least the exam component, although a number of interviewees expressed their dissatisfaction with a closed-book written exam as a means of assessing students' learning of programming. In an attempt to make invigilated exams a more valid form of assessment a couple of interviewees had moved towards open-book exams in computer labs.

> *... we have decided to have open-book exams. .... That reduces the stress for the exam supervisors. When it is closed-book they are really frightened about what type of software the students are using; can they go online, etc. .... But if it is open book then they can use any software. ... we had to create the exam so they can't simply find the answer from the internet – a small case study or scenario.* (I-10)

Interviewees mentioned different techniques to reduce cheating through individualising assessment; for example, using randomly generated questions in tests, tailoring assignment work to individual students, and allowing students to negotiate their own assignment.

> *... every student or group is doing a different task. That doesn't stop them getting help from people inside or outside the class. But it does diminish the prospect of people colluding on the same piece of work and each of them handing it in as their own.* (I-14)

Cheating on assignment work was mentioned as problematic by most interviewees. However, this was not easily resolved, as one interviewee observed:

> *The only other option I can think of [to having a programming assignment] is to have programming problems on the exam paper but the exam is not the place where you can do any thinking.* (I-13)

4.2.5 Empowering students

From another perspective, a number of interviewees described their strategies to empower students so as to reduce the likelihood that they would resort to cheating or would want to cheat. These strategies entailed supporting students, building relationships with students, and focusing on the learning gained through doing the assessment tasks.

Recognising that cheating can occur when students are under time pressure or are afraid of failing, a number of strategies were used to support students in their learning outside the classroom or online teaching environment. For example, a couple of interviewees mentioned Peer Assisted Student Support (PASS) schemes, student-led sessions that provide supplementary support for students within a course. One interviewee offered personal support:

> *I would send an email to students normally around the time the assignment is due because I think most plagiarism occurs when students get behind and the assignment is due and they*

> *quickly find a friend to copy from. I tell them if they have fallen behind to ask me, not their mate.* (I-15)

A couple of interviewees were in a position to build a relationship with each of their students. This helped them better understand their students' needs and respond more promptly.

> *We teach smaller numbers ... There is more interaction with students on a one-to-one basis ... They can consult when there are issues, able to respond quickly if they need help ... Students just about always come to class ... you're in a better position to build up relationships with them. That has an impact on a whole range of things including assessment.* (I-6)

A number of interviewees mentioned the importance of encouraging students to work for their own learning. One interviewee had designed a curriculum based on portfolio assessment for that purpose.

> *One of the big changes with the portfolio assessment was creating that really positive environment where everything was focused on learning and the assessment became secondary. If you do the learning you'll get good marks because you can show that you can do this stuff.* (I-2)

Some interviewees stress to their students that writing code is important for them to learn to work on their own, and will help them to prepare for their exam.

> *We see the assignments as learning opportunities as much as assessment. As long as the students haven't copied verbatim we're willing to accept that.* (I-6)

5. DISCUSSION AND FUTURE WORK

From our study there appear to be two main philosophical approaches to safeguarding academic integrity. In one approach, the educator designs the learning environment and assessment so that cheating opportunities are reduced or cheating is very risky for the student. In this approach the strategies directly address the particular cheating practice. The strategies in the 'making cheating difficult' theme are aligned with this approach. Some practices in the 'discouraging cheating' theme, such as monitoring the students while they work and using plagiarism detection tools, are also related to this approach.

The other approach is to design the learning environment so that the desire and need to cheat are reduced. This is achieved by building an informed, inclusive, connected, and supportive learning environment where the students' learning needs are understood and addressed. The strategies in the 'education' and 'empowerment' themes are aligned with this approach, along with some practices in the 'discouraging cheating' theme such as raising awareness of the consequences of cheating.

A key difference between the two approaches is that in the first approach the educator tends to take responsibility for stopping cheating, whereas in the second approach the educator takes responsibility for informing the students, but the students take responsibility for not cheating. Another important difference is that the first approach, using policing and scaring students to stop cheating behavior, tends to be reactive; whereas the second approach, using education and empowerment to reinforce the students' decisions to behave with integrity, has a positive focus.

An educator's personal philosophy will guide the approach they take to safeguarding integrity. For example, I-8 remarked *"We prefer to adopt a positive approach and encourage them to see us if we're stuck, rather than a punitive approach."* We found in our study that most academics employed multiple strategies

that straddled both philosophies, and it was acknowledged that no single strategy was effective in all contexts. Most acknowledged that it was necessary to put direct measures in place to make cheating difficult. For example, exams still formed a substantial proportion of the assessment and in many cases this was seen as necessary for ensuring academic integrity, particularly if a hurdle requirement was implemented. We propose that smart design of learning environments and assessments can be educationally very strong and have the added bonus of making cheating difficult.

Our work has led to ideas for future research. We have identified 21 strategies for reducing cheating but further work is needed to determine their effectiveness and how widely they are used. Further, while empowering students is an approach that academics tended to support, and anecdotally supported with the hypothesis that students tend to cheat when they are out of other options, there appears as yet to be very little research to support this as a strategy.

6. CONCLUSION

In summary, it is important that the students have trust in the academic integrity of the learning environment and that they are educated and empowered to comply with policy in this area. This study has highlighted the range of strategies and approaches that have been adopted by computing academics. It seems that it is wise to combine strategies that will discourage and prevent students from cheating with strategies that will reduce their interest in cheating.

7. ACKNOWLEDGMENTS

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