Building in Resilience through Graduate Skills Computer Science Assessment

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Abstract

Students enrolled in computing science programmes are often more focused on gaining skills such as programming than other valuable skills such as team work, adaptability and self-regulation. An ability to react, collaborate and adapt in changing environments and to evolving timelines are valuable skills required for any professional software engineering role. However, communicating the value of such skills as well as providing opportunities for students to refine skills is challenging. In this paper we argue that developing graduate skills can help students develop the necessary resilience for facing such circumstances and propose some approaches for designing such assessment in computer science.

Introduction

The importance of developing skills and attributes in future graduates from higher education has long since been appreciated by many in the sector (Hounsell, 2011). Skills should include both those related specifically to the subject as well as transferrable skills, such as communication, team work, and critical thinking. An important skill which is less explicitly recognised and discussed is resilience. A resilient computing science graduate is able to respond to unexpected challenges, resolve them and minimise disruption to themselves and others. The challenge for computing science educators is how to incorporate opportunities for students to develop their resilience. Especially when students would probably prefer to further and refine their technical skills, such as programming. In the following sections, we review existing use of resilience in transferrable skills in higher education and present examples of designing computer science degrees to incorporate opportunities for students to develop resilience.

Background

Resilience is a wide and varied topic in research, covering psychological, physiological, and educational perspectives. As a result, there are many different definitions of resilience. It is also considered to be somewhat of an ephemeral quality, thus hard to precisely define (Longley and Kensington-Miller, 2019).

Fletcher and Sarkar identified nine different definitions in their literature survey of resilience research (Fletcher 2010). One of the earliest definitions comes from Rutter who proposes that resilience is the ‘‘protective factors which modify, ameliorate or alter a person’s response to some environmental hazard that predisposes to a maladaptive outcome’’ (Rutter, 1987, p. 316). Some definitions present resilience as a characteristic inherent in an individual. For example, Connor and Davidson define resilience as “the personal qualities that enables one to thrive in the face of adversity’’ (Connor & Davidson, 2003, p. 76). Barnett (2006) also argues that resilience is a quality of a graduate. In this sense an individual is on an individual journey during their degree.

Others argue it is more of a process such as Luthar *et al.* who argue it is ‘‘a dynamic process encompassing positive adaptation within the context of significant adversity’’ (Luthar et al., 2000, p. 543). In general, resilience can be considered as being able to engage with processes which help individuals respond to challenges and risk (Zautra et al. 2010). A position that supports the argument that resilience skills can be developed. Similarly, Jackson et al. (2007) and McAllister and McKinnon (2009) argue that resilence skills are not only something an individual can learn, but can refine.

According to Quacquarelli Symonds’ (QS, the global education network) Global Skills Gap in the 21st Century survey, one of the highest valued skills is resilience. Resilience is also the skill with the biggest perceived gap between skill and expectations (QS, 2018). The ability to adapt in challenging circumstances is demonstrated very clearly in the present pandemic. Nunzio Quacquarelli, CEO of the Institute of Student Employers (ISE) notes that “development of soft skills like team-playing and resilience, often becomes as important as the technical skills and knowledge acquired during a degree” (QS, 2018).

In the context of software engineering programmes that are designed to meet industry expectations, computing science would be delivered as a highly applied subject. Most UK universities have their own version of graduate skills which they expect graduates to possess competency in. For example, the University of Edinburgh has graduate “attributes” such as “effective and influential contributors” and “critical and reflective thinkers”.

There are particular challenges in getting computing science students to engage in activities to develop these skills. Employers of these graduates note that they do not have sufficient transferable skills such as communication and team work (Begel, 2008). Indeed even technical skills are sometimes lacking. This is evidenced by Eckerdal *et. al* where computer science students nearing graduation were given a system to design, and were unable of doing so (Eckerdal, 2006). This could be due to students having difficulty transferring solutions to a similar problem (Gick, 1983).

As a result we see companies developing their own intensive training courses for new graduates. For example, Microsoft have developed training to bridge this gap as new graduates are lacking key skills and attributes (Brechner, 2003). It is clear in CS in particular that such skills need to be more explicitly designed into the degrees.

Resilience is especially important. Resilience has been shown to contribute to students’ mental health and wellbeing (Dunn *et al*. 2008, Watson and Field 2011, Hartley 2013). It is also positively linked with academic achievement (Martin *et al*. 2015). Being resilient also helps students transition from study to work more effectively (Candy and Crebert, 1991). As resilience is particularly important now, and for the foreseeable future due to the present pandemic we have chosen to focus on this.

In particular some skills have been demonstrated to contribute to resilience. McGee (2006) notes that sharing experience and reflection amongst students improves resilience. Reflection is also supported as a key skill in developing resilience by Hodges (2005), Giorando and Jackson. The importance of reflection in learning is also demonstrated in research by Larson and Brady and Wilson and Kiely. It seems natural then that reflection should be part of graduate skills.

Another graduate skill which is key for resilience is problem solving. The work of Campbell-Sills, Cohan, and Stein (2006) demonstrates a strong positive correlation between task-oriented coping

(through problem solving skills) with increased ability to recover from disruptive situations. Other studies also evidence this (Penley *et al.* 2002 and Zeider *et al.* 1996).

Having identified two key attributes which assist students in developing resilience in the transition to work, the next step was to establish whether UK universities did indeed recognize these skills.

Review of Resilience Related Graduate Skills in UK Universities

To determine this, we reviewed 10 universities, and identified the following use of resilience or resilience related qualities as part of their graduate skills material. It is important to note that we could only access externally facing information on these websites. It is possible that some Universities where we could not find information on graduate skills do have these, but do not advertise them externally. In our review, it was clear that many universities appear to recognise the importance of resilience, though this is not always explicit or in similar terminology. Two broad themes emerged regarding resilience, specifically adaptability and integrity.

Adaptibility can be considered part of resilience as Rutter's definition notes how resilience are factors including modifying one's behavior. Durham University identify adapting to change as one of their graduate attributes. The institution identifies some ways of demonstrating this skill, including changing module and completing placements or study abroad. Durham consider it almost as a part of life. That balancing University studies alongside changes in assessments results in improved adaptability and resilience.

Newcastle, Glasgow and Warwick also refer to adaptability, as part of self-management or life skills. Newcastle University also touch on adaptability and identify it as part of a student's self-management. The University of Glasgow note that managing multiple workloads and deadlines as well as independent research and dealing with unfamiliar equipment and collaboration with new people are all ways of developing this skill. The University of Warwick also have a similar approach and identify their students as adaptable.

As with many of the graduate skills which were reviewed, there was no explicit evidence of adaptibility skills being designed into assessment. It was more akin to being developed by the journey as a whole. An interesting consideration here is the potentially negative impact of developing adaptability through this approach. In an effort to manage multiple deadlines or challenges presented in completing their studies, without sufficient support in developing adaptability, a student may resort to tactics such as plagiarism, collusion, or payment for essays or other coursework. This is clearly not the behaviour Universities wish students to develop as part of resilience. The potential for such behaviour could be seen as a reduction in academic integrity.

Integrity is the second theme which arose from the review. For example, the University of Edinburgh states that students should demonstrate personal effectiveness, which they define as reacting to situations with "sensitivity and integrity". It could be argued that Edinburgh focus on controlling risk, such that students have to consider that things might change and be prepared for it. This links once more to adaptability and integrity. Similarly, the University of Liverpool wrap resilience up in the concept of a confident graduate, noting such students are "curious, creative, proactive and resilient". They also relay the need to apply skills in unknown situations.

Imperial College London argue all students should have a set of core competencies. Including applying problem solving skills to real world problems, being independent learners with high self-efficacy, and a strong sense of personal and professional identity. Of particular interest here is

the problem solving aspect, which was previously identified in research to contribute to resilience (Penley *et al* 2002, Zeider *et al* 1996). Being able to problem solve and think creatively arguably is a more refined way of saying adaptability, with clearer intentions for a students' integrity.

Exeter University is one of the few universities surveyed which explicitly identifies resilience as its own attribute. Exeter graduates are said to be able to demonstrate resilience and adaptability, again highlighting integrity and in particular effectiveness despite personal circumstance. The University of Sheffield also explicitly use the word resilience as part of their student attributes. Queen Mary London appear to suggest 'initiative and resilience in meeting challenges' around the idea of adapting prior knowledge to new situations and reacting to criticism.

Integrity seems to be tied to the individual student. Students must react in a personal and professional manner, possibly via internal reflection but also how you react to others around, such as with team work. A common occurrence is when a team member lets you down. It is expected students should be sufficiently resilient to deal with this in a professional manner, not giving way to frustration or anger, but instead finding a productive way forward for the team. Similarly, given a challenging assessment, or multiple assessments due in a short period of time, students should be sufficiently resilient to not give way to the temptation of plagiarism or poor scholarship.

One could argue that given the general by-product nature of graduate attributes (as they are currently communicated) students could be unaware of the importance of resilience, how to develop it, and its role in their degree. Should we be incorporating opportunities to develop skills which increase a student's resilience toolkit more explicitly in a student's studies? In the next section we propose one approach is to incorporate opportunities to develop resilience through assessment, taking particular note of the challenge in computing science.

Incorporating Resilience Skills in Assessment

The challenge is how to incorporate opportunities for students to development resilience in the higher education context. Students may be reluctant to experience group work and peer review, but we would argue students should experience this early and often at least from the perspective of developing skills affording resilience to changing situations.

There are mechanical ways this method could be developed in terms of clarity around why students should deal with deadlines and changing assessment specifications. However, while this may develop some resilience to change – the concern is that it may produce undue stress or could result in individuals react in unpredictable ways – such as plagiarism.

However, it is important that students are able to recover and respond to criticism and failure it also important for students to be able to support others. The established approaches of group work and peer-review could provide opportunities for students to develop and refine skills affording resilience to changing situations.

Group Work

A typical approach to developing resilience is group work. This helps students develop resilience by working with others who may have different priorities or skills, and may let them down. However, computing science students are notorious for their dislike of group work (Rebelsky and Flynt 2000, Brown and Dobbie 1999, Drury 2003). This is often referred to more generally as grouphate (Sorensen, 1981). This often emerges as a result of perceived lack of contribution by

others in a group, dissonance of working styles, reacting to feedback for improvement, and conflict resolution such as when individuals do not meet deadlines.

However, these challenges are where resilience is developed. Thus, it is important to recognise the balance of supporting students in developing resilience e.g. through guidance on aspects such as conflict resolution and clear inclusion as part of the assessment criteria, whilst students the opportunity to find their own approaches.

This of course still presents challenges for students who may not engage with the support. One possible approach which could identify challenges resulting from this is that of Largent (2016). Largent studied team development for a capstone Computing Science project over 5 years with 9 cohorts and 215 students. During this time Largent asked students to complete questionnaires every one to two weeks. The questionnaires were Likert scale questions which asked students about their perceived skill level and enthusiasm. For example enthusiasm could be related to a question such as “I am happy to be part of my team”. A question related to skill could be “I need to improve my skills to do my team job well”.

An interesting part of this work is demonstrated by example in Largent’s paper. He notes how the frequent questionnaires allowed him to recognise a team facing challenges, such as the team who repeatedly noted one member was not contributing. This allowed Largent to review the responses in terms of that individual’s questionnaire. The student identified as needing to develop their skills before being valuable to the team. Having a clear indicator of this issue and gaining deeper insight into the individual’s perception of why they are not engaging could allow a more focused intervention.

Peer Review

Another approach to help students develop resilience is peer review. This provides students opportunities to reflect on their own work, as well as that of others. It also helps students experience the process of feedback from peers, and develop their skills in dealing with critique of their work. Once more we argue it is important to provide students support in such interventions.

This is seen in Mercader *et al.* (2020) where students report preferring longitudinal interventions, with clear face to face instruction and the opportunity to adjust their practice. In computing science developers frequently review others code, so not only is this a general skill which is important for any graduate, it is key for computing students particularly. It would be unfavourable for a student to receive feedback on their code once in a job, and to react poorly to this. Peer review also provides an opportunity to see others work, but also establish a clearer sense of what is expected.

As Epp et al. (2019) note, reflective writing in computer science education is limited, but this can be incorporated into peer review to further develop resilience. Epp et al. do this by incorporating reflective writing and peer feedback activities into the assessment for the course. Students were pointed to resources on reflective writing and prompts for reflection on the specific topics used in the course. Students were asked to review others reflections. By completing this repeatedly throughout the course students had the opportunity to reflect on the process, and develop their approach in line with feedback and rubric guidance.

Conclusion

The expectation of many employers is that graduates from computing science degree programmes not only need to possess technical skills such as programming, but also need to be resilient to unforeseen challenges. The expectation is that many higher education institutions

expect degree programmes to provide opportunities for students to develop and refine skills, such as resilience. Computing science educators can support the development of resilence in their students through careful use of assessment, scaffolding students with approaches such as group work and peer-review.

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