Exploring Learner Resilience and Performance of First-Year Computer Science Undergraduate Students during the COVID-19 Pandemic

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ABSTRACT

This paper presents the findings from a research project exploring the impact of learner resilience as part of the shift to online delivery of learning, teaching and assessment amidst national social "lockdown" measures as a result of the COVID-19 pandemic. This exploration of resilience was undertaken as part of the delivery of a first-year undergraduate computer science degree programme in a UK higher education institution over two academic years. Resilience was measured by the Nicholson McBride Resilience Questionnaire (NMRQ). The responses from the 2019-20 and 2020-21 student cohorts (N=214) illustrate that overall learner resilience as measured by NMRQ does not appear to have had a significant impact upon learner success as measured by the mean overall first-year performance. This is an outcome that differs from previously published work and may be a consequence of the unusual and ongoing circumstances arising from the pandemic. However, the factor "*I try to control events rather than being a victim of my circumstances*" appears to promote success and the factor "*I trust my intuition*" may have been slightly detrimental to overall success. As we start to consider the post-pandemic new (ab)normal, learners will continue to face significant personal challenges that will impact upon their engagement with their studies and their performance and progression; thus the insights offered from this UK university study can help to inform emerging academic and pastoral practice for undergraduate computer science education.

CCS CONCEPTS

• **Social and professional topics → Computing education**.

KEYWORDS

Resilience, Effective Learning, Learner psycholology

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1 INTRODUCTION

Learner resilience is recognised as contributing to effective learning and successful study outcomes in higher education in general [29, 33, 57] and within computer science education in particular [18, 19, 39]. University-level study is a period of significant transition for all learners [54] and can presents specific significant challenges for many learners new to the discipline [8, 14, 22].

There are specific disciplinary challenges in the learning of computer science (CS); for example, learning programming for the first time remains a significant hurdle [23, 35, 41, 52], with a range of issues impacting failure rates [62]. For some, these challenges are further exacerbated, as for university-level study in the UK (and indeed other jurisdictions), it is still possible to embark upon the study of CS without formally studying the discipline (or obtaining any qualifications in it) during compulsory education. As such, it is common for UK degree programmes to assume little (if any) prior knowledge in the discipline. Competence can be seen as the related skills and knowledge a learner possesses [58]; so for first-year student it will initially be determined by the knowledge, skills and experiences students arrive with and further develop as part of their studies. Whilst prior knowledge is not assumed, the initial competence in CS first year learners will exhibit is varied and may impact upon the challenges individuals face in study.

Initial competence, is not everything – *positive psychology* [48] – a reflection of optimism in the face of challenges is also important in maintaining effective learning. An individual's positive psychology can be enhanced through educational interventions [20, 29, 57], although such interventions can have mixed results [41].

For the 2019-20 and 2020-21 student cohorts, challenges in study were further exacerbated by the move to online learning, teaching and assessment precipitated by national social 'lockdown' measures demanded by the global COVID-19 pandemic. At the time of writing, in early 2022, we are only slowly starting to see a shift away from the depths of the pandemic (but this is unevenly distributed across the world, especially looking at global vaccination statistics [45]), and into a new (ab)normal. From the "emergency remote teaching" phase of 2020, to the more planned online and hybrid delivery from late 2020 and into 2021, we have seen widespread and significant impact not only on educational activities, but also research and innovation, outreach and engagement, and essentially every activity that takes place at universities [59–61]. The impact of the pandemic on the wider education system, across all settings, has been profound [56], presenting significant challenges for learning, teaching and assessment [25, 28, 44] – and how face-to-face learning is somehow perceived to be "better value" than online approaches [13, 37]. In the UK, there have been major responses from governments, organisations and institutions at all levels and settings; from major national policy initiatives to support learners and maintain quality and standards across all settings, to major

government inquiries on the longer-term impact of COVID-19 on education and children's services.

However, further to the ongoing and varying impact of COVID-19, how an individual responds to the challenges presented by transition to university-level study in CS may be influenced in part by their sense of optimism or more formal their *positive psychology* [48]. One aspect of positive psychology, namely resilience, *"the ability bounce back from tough times or even triumph in the face of adversity; to display tenacity, but not at the expense of reason"[11, p. 1]* is explored in this paper. In particular, the resilience of first-year computer science students and its impact upon success in their studies as measured by their first-year mean mark.

2 RELATED LITERATURE

Successfully transition to university study requires a learner to learn how to adjust to the demands of university study i.e. how they become effective learners. Effective learning can be seen to be when learning achieves the desired result [30]. There is considerable published work related to the promotion of effective learning and how learning is significantly impacted by learner engagement, and blockers to it [30, 43]. It has long been recognised [54] that learner success, as indicated by their continuation with their study, is influenced by student attributes and experience combined with institutional factors. These attributes include: previous educational input, family history and the individual's own abilities whereas the institutional factors focus on achievement while at university and faculty interactions. Further work [4, 10], has focused upon individual elements of this model and focusing primarily on institutional factors. Other studies have considered the relationships between student success and student attributes, including gender [32], pre-entry grades [38] and previous experience [42].

In additional to the typical challenges to transition to university study, the 2019-20 and 2020-21 cohorts of learners in the UK, faced a further set of challenges, those presented by the rapid and ongoing move to online learning, teaching and assessment introduced in response to the measures introduced in response to the COVID-19 pandemic. This necessary paradigm shift has compelled educators to take a critical look at their teaching styles and use of technology; for the discipline of computer science, which traditionally focuses on experiential, in-person activities, the pandemic has mandated that educators reconsider their use of student time and has catalysed overnight innovations in the educational setting [17, 49]. Even in the unlikely event that we return entirely to pre-pandemic norms, many new practices have been developed and emerged that offer valuable lessons to be carried forward into our post-COVID-19 teaching, from pedagogy and practice [16], through to community, belonging, inclusion and diversity [50].

Seligman [48] argued that there is *"third factor – optimism or pessimism – that matters as much as talent or desire"*[48, p. 13] and that furthermore you can learn to be both optimistic or helpless. Socioeconomic, societal issues and context have a part to play and may influence a learners beliefs about their academic capabilities, motivation to achieve and ability to overcome difficult challenges [3, 63]. Transition to university may require learners to triumph in the face of adversity (although the adversity face may vary by the individual) and hence exhibit resilience.

Arguably all disciplines present specific challenges in the curricula studied; so-called *"threshold concepts"* and *"troublesome knowledge"* [34]. Within the CS discipline, threshold concepts are reported to be related to programming [23, 47]. Research related to teaching fundamental programming or "CS1" is very active and continues to promote improvements to learner success in the discipline. This focus upon CS1 can leave a gap in our understanding of factors that promote success [9, 31, 40]. Specifically, when learning troublesome knowledge, learners may need to face and overcome a challenge. As such a learners' positive psychology and the further growth to that positive psychology may be beneficial to learning threshold concepts. More precisely leaners may need to display tenacity i.e. exhibit resilience.

It is possible to view positive psychology through many alternative lenses. Work by Dweck [27] establishes that an individuals *Mindset* can impact upon their performance and there are two Mindsets (1) Growth i.e. talents can be developed and (2) Fixed i.e. talents are innate. Studies in schools [7] and for introductory programming classes [20, 41] have shown strategies can be employed to promote a growth Mindset, although the approaches are not universally successfully for all learners [41]. Duckworth et al. defined the term grit as *"perseverance and passion for long term goals" [26, p. 1087]*, representing the desire to achieve and determination to overcome challenges. Duckworths' work relates grit with higher education success. Grit is not without criticism; the extent to which it promotes success is reported to vary depending upon educational contexts [21, 55], suggesting there may be cultural differences that have an influence upon its effectiveness. The prediction of CS1 performance based upon Grit [51] has been attempted, although it was not successful. Bandura's theory of self-efficacy [3] refers to an individuals belief in their capacity to execute behaviours to produce specific performance attainments. Self-efficacy in a CS context has been explored a number of times, in the context of CS1 [42, 53] or CS more generally [6] and it appears to be an important factor.

Several scales exist which measure resilience [1]; resilience is reported as having an impact upon study during the pandemic [19, 24]. In this work the selected approach is to use the Nicholson McBride Resilience Questionnaire(NMRQ) short version [11]. NMRQ is a shortened version of the Nicholson McBride Resilience Questionnaire (12 questions reduced from 64) [11, p. 157]. NMRQ is reported to be related to student success [39] and having some influence to learner behaviour during the pandemic [19]. This definition of resilience this scale is preposed to measure *"the ability bounce back from tough times or even triumph in the face of adversity; to display tenacity, but not at the expense of reason"[11, p. 1]* is seen as consistent with the educational challenges of higher education study and the challenges of study during a pandemic in particular.

3 RESEARCH QUESTIONS

Three research questions are considered as part of this study:

RQ1: Has the experience of the pandemic, coupled with enhanced pastoral and personal support provided to learners, grown the resilience of the learner community?

Table 1: Overview of Sample

Year	Sample size	Cohort Size	NMRQ Score		Year Mean	
			Mean	SD	Mean	SD
19-20	113	183	43.6	4.9	68.8	18.0
20-21	101	176	41.9	5.7	63.7	17.4

RQ2: What is the relationship between first-year CS leaner success and resilience (NMRQ) during the COVID-19 pandemic?

R32: What is the relationship between first-year CS learner success and individual NMRQ factors during the COVID-19 pandemic?

4 DATA COLLECTION AND POPULATION

Data was obtained as part of the delivery of a class delivered to first-year core subject on a computer science degree during the second week of teaching in the second semester (in early February). The 2019-20 and 2020-21 cohorts of the computer science programme where both asked to complete the NMRQ short survey. Students were asked to complete the NMRQ survey using Microsoft Forms and afterwards were encouraged to reflect upon their results which were discussed as part of the class. The students were supported in the interpretation of their results and guidance was provided regarding strategies they could adopt to improve them in the context of their degree studies. The study was approved by the university's ethics system and students were specifically asked for consent to use their data for research. Data on student performance was obtained at the end of the teaching year and consists of the results over both semesters of the academic year.

The data set is comprised of the responses from the students who formally consented to use their survey. The NMRQ surveys comprised 12 items, phrased as statements, answered on five-point Likert scales from "*strongly disagree (1)*" to "*strongly agree (5)*". Scores for NMRQ are added together, yielding total scores between 12 and 60. The NMRQ questions can be seen in Table 2.

The NMRQ results from 2019-20 were captured prior to the COVID-19 Pandemic. The NMRQ results from 2020-21 were captured during the COVID-19 Pandemic. The academic calendar consists of two 15 week semesters, with 12 weeks of teaching followed by 3 week assessment periods. The 2019-20 cohort were taught in a traditional face-to-face manner until the first UK wider 'lockdown' was introduced in March 2020. For the 2019-20 cohort, the 'lockdown' resulting in a the online only approach being introduced for the final 6 teaching weeks and the summer assessment period. The 2020-21 cohort were taught in a blended delivery (4 1/2 hours a week of face-to-face teaching supplemented by 4 1/2 hours online synchronous delivered classes and 3 hours of asynchronous material) for the first semester. Due to 'lockdown' measures the second semester was mostly delivered online with 1 hours / week delivered face-to-face for the last 4 weeks of the semester; Table 1 provides an overview of the results obtained.

5 METHOD

The data was analysed by a combination of R (v4.1.2) using R-Studio and Orange Data Science (v3.20.2). RQ1 was explored first. This was by analysing the sample NMRQ responses between the two cohorts using a t-test (Welch's t-test). This would serve to indicate if experience of living through the COVID-19 pandemic, coupled with the additional support measured that had been put in place had raised a subsequent cohorts Resilience with respect to the previous Cohort. The 20-21 cohort benefited from enhanced pastoral care from personal tutors and their programme leads designed into the programme delivery, whereas the 19-20 cohort had benefited from a more traditional face-to-face educational experience for one and half semesters of study. The result from this T-test together with a T-test for the difference of mean year marks between cohorts were then used to establish if there was a reasonable statistical basis for treating the datasets as a single combined data set or whether the analysis should continue with two separate data sets.

RQ2 was then explored. Correlation analysis was employed to provide an indication as to whether or not resilience is related to overall year average. If there is a high degree of correlation between a psychological measure and a measure of performance then it is likely that the former will be predictive of the latter.

Finally RQ3 was then explored. Correlation analysis again employed to provide an indication as to whether or not the individual NMRQ factors of resilience are related to overall year average. If there is a high degree of correlation between a NMRQ question and overall year mean then it is likely that the former will be predictive of the latter. This was followed by the use of analysis of variance.

A Binary Tree of the Year Average based upon the individual NMRQ questions and NMRQ Score was then produced. This was produced via Orange Data Science. The algorithm employed by Orange Data Science employs Logistic Regression in order to find the tree that is of best fit. The minimum number of instances in leaves was set to 15, subsets of small than 5 were not split, the maximum tree depth was 10 and the search stopped when 95% of data points were classified. The tree was then analysed using T-tests to determine which node splits represent statistically significance difference at the 5% level. This was performed to support visualisation of any relationship between NMRQ, NMRQ questions and overall first year mean.

6 RESULTS

6.1 RQ1: Has the experience of the pandemic grown the resilience of the learner community?

A test-t (H0: NMRQ Scores are equal between years) provides confidence that the overall results for the two years are comparable (t = -0.46, p-value = 0.65).There is very little difference in the mean of NMRQ score for leaners who completed it before the COVID-19 Pandemic and those who complete it after the COVID-19 pandemic. During the COVID-19 pandemic, students, academic faculty, professional services staff, and the wider world have had to adapt to alternatives ways of working. On occasions these presented challenges to all involved and addressing these challenges could have help grow the resilience of those involved. However in terms of resilience as measured by NMRQ there is not evidence that is the case. Also, additional support mechanisms have been put in place for the 2020-21 cohort. These measures do not appear to have influenced NMRQ either.

Table 2: Analysis between Mean Year Mark and NMRQ questions

No	NMRQ Question	Correlation			ANOVA	
		r	t	p	F	p
Q1	In difficult situations, my thought turn immediatelly to what can be done to put things right	0.07	1.01	0.31	1.03	0.31
Q2	I influence what I can rather than worry about what I cannot	0.08	1.23	0.22	1.53	0.22
Q3	I dont take criticism personally	-0.10	-1.56	0.12	2.41	0.12
Q4	I generally manage to keep things in perspective	0.001	0.01	0.92	0.01	0.92
Q5	I am calm in a crisis	-0.09	-1.22	0.20	1.62	0.20
Q6	I am good at finding solutions to new problems	0.08	1.22	0.22	1.48	0.22
Q7	I wouldn't describe myself as an anixious person	-0.08	-1.22	0.22	1.50	0.22
Q8	I don't tend to avoid conflict	-0.09	-1.29	0.20	1.67	0.20
Q9	I try to control events rather than being a victim of my circumstances	0.21	3.19	0.002**	10.19	0.002**
Q10	I trust my intuition	-0.15	-2.20	0.03*	4.83	0.030*
Q11	I manage my stress levels well	-0.02	-0.32	0.74	0.10	0.75
Q12	I feel confident and secure in my postion	0.03	-0.39	0.7	0.15	0.70

** **significant at 1% level** * **significant at 5% level**

A test-t between (H0: Year Averages are equal between years) provides confidence that the overall results for the two years are comparable (t = 0.45, p-value = 0.65).

As there is statistical evidence of comparability of both NMRQ Scores and Overall years results, on this basis the two cohorts are considered as one sample.

6.2 RQ2: What is the relationship between first-year CS learner success and resilience (NMRQ) during the COVID-19 pandemic?

The Pearsons Correlation Coefficient between Mean Overall Year Mark and the MNRQ statistic was 0.02. Needless to say this is not statistically significant. There related T statistic being t=-036 with a p value of 0.72. This is different to results reported elsewhere [39]. This may be due to impact of the pandemic or it could be that these result or those pointed elsewhere are atypical.

6.3 RQ3: What is the relationship between first-year CS learner success and individual NMRQ factors during the COVID-19 pandemic?

The Pearson Correlation Coefficients, related T statistics and P values can be seen in table 2. Q9 'I try to control events rather than being a victim of my circumstances' is statistically significantly correlates with the mean year score (r=0.21, t=3.19 and p=0.002). Q10 'I trust my intuition' is statistically signifiantly correlated at the 5% level.

The table 2 shows the results for a set of analysis of variance tests (ANOVA) between the individual NMRQ questions and mean first year mark. Again, Q9 'I try to control events rather than being a victim of my circumstances' is statistically significant at the 1% level (F=10.19 and P -0.002). Q10 '*I trust my intuition*' is statistically significantly correlated at the 5% level (F=4.83 P = 0.030).

The Binary Tree in Figure 1, again emphasises the importance of Questions 9 and Question 10. Validating the Binary tree with T-tests it can be seen only the that at the 5% level there are statistical differences in the mean mark achieved by learners who answered Strongly Agree', 'Agree' or 'Neither Agree nor Disagree' to Q9 '*I try to control events rather than being a victim of my circumstances*' (T=2.25, p=0.004) with those that did gaining a higher mark on average than those who didn't. Then for those who did answer 'Strongly Agree', 'Agree' or 'Neither Agree nor Disagree' to Q9, there are statistically significant differences at the 5% level for those who 'Strongly Agree' with Q10 'I trust my intuition' with those who did on average obtaining a low mark than those who didn't. Figure 1 only shows the tree to a depth of three as beneath this depth the differences can not be shown to be signifiant with T-Tests.

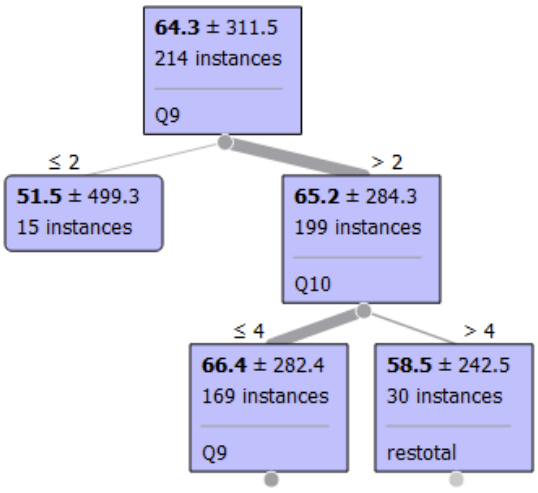

Figure 1: Binnary Tree of Year Mean Score by NMRQ questions and total

7 THREATS TO VALIDITY

There are a number of threats to validity of this study:

(1) Whilst a reasonable response rate has been obtained from both cohorts, the response rate is not 100% so there may be differences in terms of resilience and students success in the none responding students;
(2) This is a relatively small sample from one programme of study at one university. How the study is situated may have had some impact upon the results;
(3) The data was collected as part of a series of taught seminars which took place across a week. As part of the seminars the meaning of resilience was explored together with general guidance regarding growing resilience. It is possible learners who scheduled earlier in the week may have influenced the responses of learners later in the week;
(4) The assumption is the learners complete the survey honestly, however since learners are cognisant that academic faculty will be aware of the results this may influence the responses provided.

8 DISCUSSION

Learners from the 2019-20 and 2020-21 cohorts exhibited very similar levels of resilience as measured by the NMRQ short survey. Whilst the taken definition of resilience [11] feels directly pertinent to how an individual may respond to the pandemic, other factors may be at play. However, whilst people tend to adapt to challenges over time, partly related to their resilience, the adaption to challenges in itself will not grow resilience, growing resilience typically requires intent [2]. Whilst the learners in this study have received additional personal and pastoral support from academic faculty acting as their personal tutors, programme tutors and as part of their taught classes this support does not appear to have directly grown the resilience of the learners involved. The guidance provided as part of the completion of the resilience surveys were intended to promote resilience, but this is beyond the scope of this work. Publications have suggested "growth mindset"-related approaches can be make a positive contribution for some learners [20, 41].

In this study resilience as measured by NMRQ had no discernable relationship with overall success as measured by year mean mark. This results is different to previous and similar study [39] which evidenced statistically significant correlations between resilience as measured by NMRQ and learner success. The pandemic has presented different challenges to different individuals depending upon their own personal circumstances. It feels likely that the extent an individual has faced challenges during the pandemic may be having a more significant impact upon their success as measured by their year mean mark. Equally, it is possible the recent findings by [39] are not reproducible.

NMRQ Q9: *'I try to control events rather than being a victim of my circumstances'* appears to be related to overall success as measured by year mean mark as shown by correlation analysis, ANOVA and by the production of a binary tree. In particular, learners who are not trying to control events and hence may become victims of the circumstances they find themselves in appear to be performing less well than those who do. Interesting this parallels the advice given in the 'serenity prayer' to *"grant me the serenity to accept the things I cannot change, courage to change the things I can, and wisdom to know the difference."* [36, p. 1] which has been adopted by a number of twelve-step programmes [12] to aid recovery from a variety of extremely challenging circumstances. Arguably it is apt this applies to succeeding within the challenges of a pandemic as it does in other unusually challenging circumstances.

NMRQ Q10: *'I trust my intuition'* appears to be significantly related to overall success as measured by year mean mark as shown by correlation analysis, ANOVA and by the production of a binary tree, albeit with less statistical confidence than Q9. This maybe related to learner attitudes to seeking help and support. It is been reported that despite encouragement from academic faculty many students remained reluctant to turn their webcams or microphones on during online classes, meaning that in many classes the lecturer has left looking at blank screens during online classes in the pandemic [46]. This may have made it more challenging for a member of academic faculty to confirm whether a learner has understood the course content or assessment task etc. Leaners who are trusting their intuition, may be less inclined to confirm their understanding of tasks and assessed activities. If the same learner is also behind a blank screen and closed microphone it may challenging for academic faculty to provide the required assistance.

9 CONCLUSIONS AND FUTURE WORK

Many of the challenges and opportunities presented by COVID-19 and the rapid shift to online learning, teaching and assessment for the discipline of computer science could be applied more broadly across the various educational settings in the UK. We have seen – and we will likely continue to see into 2022 and potentially beyond – further shifts and changes to the provision of computer science degree-level education in the UK, and what this means for not only students, but also for academic faculty and professional services staff. This is supported by widespread evidence, both in the UK [16, 60] and internationally [17, 50], of potentially permanent changes to pedagogy and practice (especially assessment); academic integrity; values; inclusion and diversity; and community, belonging and wellbeing [49, 50]. For learner resilience, and ultimately performance and progression, there are a number of interesting future avenues of research to explore, acknowledging the ongoing and unevenly distributed impact of COVID-19 on our various student communities, staff and wider society [15, 50, 61].

In terms of RQ1, the study provides some evidence that the resilience as measured by NMRQ has not grown by experience of living in the pandemic or additional support mechanisms that have been put in place. Cohorts of learners who completed NMRQ survey before the pandemic have very similar NMRQ scores to those who completed the NMRQ survey after the pandemic

In terms of RQ2, overall resilience as measured by NMRQ is not related to overall year mean for learners completing their studies during the pandemic. This suggests that either the results obtained by [39] were unusual or that during the pandemic other factors are becoming predominant. It has been reported that remote working may have intensified social and digital inequality [5] so these and other factors may have played a more significant role than with traditional face-to-face delivery.

In terms of RQ3, the NMRQ questions Q9: *'I try to control events rather than being a victim of my circumstances'* and Q10: *'I trust my intuition'* appear to be having a significant impact upon overall success. This is suggestive that inventions which directly target these factors may be beneficial to overall learner performance within the ongoing global pandemic and for leaners who face significant challenges post-pandemic.

In terms of further work, better understanding the impact of learner resilience or aspects of learner resilience in computer science presents a potentially productive avenue for future research.

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