Climbing Everest: Encouraging student resilience, long-term motivation, and lasting value in challenging projects.

Cite as;

Bustard, J, Gibson, Z. 2020. Climbing Everest: Encouraging student resilience, long-term motivation, and lasting value in challenging projects (Study 285) IN: Queen's Assessment Hub.

Available from:

https://go.qub.ac.uk/assesshub

Summary

For computer science and many other disciplines, a student's university career is concluded with a capstone project. A demonstration of a student's skills and a validation of their ability to work independently on a substantial piece of work. Students often learn a great deal during their projects and the experience is valuable for obtaining their first job in graduation as it is similar to experiences they may have in the workplace. This case study describes a new module that provides a final year project-like experience for first year undergraduate computing students. The module emphasises the importance of self-learning and resilience. It goes further than traditional final year projects in emphasising the importance of creating work that is useful to others and that could form the basis for a start-up company or a research career. The module uses a number of techniques to increase student motivation and encourage high levels of perseverance and effort.

The module demonstrates that, when suitably motivated, students can teach themselves very advanced technical material. It also demonstrates that there are a number of students who are capable of extremely high levels of productivity and learning at the beginning of their university education and that these students are potentially well suited to entrepreneurship if effectively supported.

Description

This case study focuses on a group of first-year undergraduate Computer Science students who self-selected into the 'Computer Science Challenges' module. This was a difficult module where students would complete a one-semester long project similar to a final year project. The module focused on a 'coaching' rather than 'judging' style. Students met with the module supervisor weekly. They prepared diaries that tracked their plans, progress and problems. Students were encouraged to communicate in an 'unfiltered' way, expressing their feelings and any factors affecting their work. They were praised for their transparency and for their efforts towards working steadily on the project.

Students were working to advance their career rather than participating in a competition or intelligence test as the deliverables for the module enabled students to share and showcase their abilities online to directly help their career. Highly motivated individuals were guided to remain on a path to impact whereas low motivated students were supported to maintain a steady progress. This one-to-one, tailored support was designed to create an effective learning environment for all students, upskilling them regardless of entry level.

The module encouraged the focus on useful outcomes of project work. The projects offered were high status, technologically sophisticated projects and students could have approached the projects as a means of proving their skills rather than making something useful. Through meetings, feedback and interim assessments, students were given clear guidance on the importance of creating practically useful work for others. Students were encouraged to adjust the objective of the project to maximise the useful outcomes for others. The goal was not to achieve an objective but to produce the most impact starting from an initial idea. This was intended to replicate an entrepreneurial/research approach. Supervision ensured that this flexibility was not used to reduce the effort or challenge required to complete the project.

There was an 11-step approach used in the module:

1) The module was introduced to students, described as being to challenge students with existing technical expertise (self-taught programmers)
2) All students completed an online questionnaire discussing their expertise in different technical areas e.g. programming languages. Students were advised to take the course or not based on the results. The questionnaire was not a requirement but served to set expectations.
3) Students then self-selected into the module
4) Students received an introductory lecture describing the challenging module; specifying the importance of steady work, perseverance and useful outcomes. Students were told they were assessed on their approach to a challenging problem rather than completing a task.
5) Students selected their chosen project from a variety of one sentence project proposals (~150 projects). They were encouraged to select one outside of their current knowledge (i.e. a tangible challenge) but that they would be impressed by if someone else had done it (helping maintain interest and motivation). Students were given an online tutorial or piece of source code relevant to the problem as a first step for their project.
6) Students were assigned a weekly meeting in pairs (with students doing a similar project) and were given a diary structure to complete weekly.
7) In their weekly meetings students were given guidance and targets to complete for the next week. Their diaries were used for discussion points on barriers to their motivation/work output, knowledge gaps, work completed from the previous week and their plan for the next.
8) Students' first deliverable was an online How-to guide explaining the skills developed in the initial stages of their project. The students could showcase their learning and develop a guide for others to learn the same challenging topic.
9) The next few weeks were spent developing and refining the software relating to their project and any relevant guides that might help others pursuing a similar objective.
10) The students were tasked to polish the project, they had developed something useful and now had to refine the project into something the users could develop or use to build their own skills. Students had to think in a different frame of mind; the project's usability and how it helped others. Students were tasked with creating a social media post to promote and explain their project to the respective community that the work could impact.
11) Lastly, students submitted their weekly diaries, their project outputs in a GitHub repository and their how-to guide and social media post for evaluation.

Motivation and Aims

It is evident from the literature that students struggle to adapt and adjust to the independent working style of University. Often as a result, during their studies they fail to learn and engage more deeply and widely with their course and course content. They focus on the type of learning that facilitates answering exam questions rather than learning to develop building blocks of knowledge that can be flexibly and adaptively applied in new scenarios. Halpern & Hakel (2003) outline basic teaching principles that facilitate long term retrieval and transfer. These include simpler approaches such as practising retrieval, re-representing information in different ways and avoiding the type of recall that facilitates selective forgetting. Specifically, applicable to this case study are the principles of varying learning conditions, considering prior knowledge and experience in the outline of what and how much is learned, promoting

experience of real-life scenarios with systematic and corrective feedback about the consequences of various actions. The authors note that lectures work well for learning that is assessed with recognition tests but work badly for understanding. This last aspect is one of the most problematic to student learning. It is possible for students to gain high scores on tests but be unable to recognize a given concept's application in a slightly altered context, or not be able to apply the concept at some time in the future.

In addition to students' lack of in-depth learning around their course content is the lack of development of transferable skills. Students expect their experience in University to increase their employability and lead them to a career but, largely, their employability does not rely on their academic qualifications but rather their ability to apply this academic knowledge to the variation and flexibility that occurs in a specific job role. Students' inability to do this is reflected in the identified 'skills gap' between what students learn and develop in University, and what employers need and expect from graduates. In particular, 'soft skills' including flexibility, problem solving, resourcefulness, accepting feedback and creative thinking are commonly cited as aspects where graduates fail when transitioning into employment. Resultantly, finding ways to foster these soft skills for graduates to succeed in their future employment is vital.

Thirdly, an internal motivation for this study was an understanding that there is a consistent problem in student project work having lasting usefulness and impact. Students tend to create prototype demos but these are rarely finished to a polished standard where either another student can come along behind and pick up the project, or to a level where the project is lastingly useful for others. Students are often attracted to projects to showcase their skills and capabilities rather than to produce something enduring. Reminiscent of task verses ego orientation theory, the goal is to encourage students to move from ego-motivated working to more task-motivated working.

The purpose of this case study is to:

- Describe a new individual project-based module for students that promotes independent learning
- Determine what factors or traits influence student success on the module, such as task or ego-based motivations
- Foster the development of soft skills such as problem solving, creativity, user focused design and perseverance through completion of the project

A successful module outcome would be the creation of graduates that are increasingly employable due to the development of desirable soft skills and their increased self-sufficiency. There is also potential to monitor the students' progression in their degree to accumulate longitudinal evidence about how the benefits of self-regulation develop over time, which is lacking in current literature (Duckworth, Akerman, MacGregor, Salter, & Vorhaus, 2009). It is the goal that the most successful students can develop their projects to become start-up companies or the basis for a research career.

Methodology

This case study focuses on a group of first-year undergraduate Computer Science students. These students self-selected into a module titled 'Computer Science Challenges'. The module was described as a difficult module where students would complete a one-semester long project. The course was designed to intensify motivation. Initially, the self-selection into the challenging module attracted students that strived for the difficulty the module would offer, they were drawn by the power of an ambitious challenge. An initial presentation further emphasised the nature of the module. The introductory lecture explained that most educational courses focus on training students to be employees but this course trains students to 'be the boss', which includes having energy and focus and being able to solve any problem, efficiently. These skills are described as being present in leading technology entrepreneurs or other technology leaders, including academics who develop new ideas and products. The module was designed to be 'hack-proof', in other words they could not 'game the system'. Most of the students on the course had traditionally done well in education and many of them had got used to doing work at the last minute, partly as a proof of their skill, partly because they see gaming the system as being what they should optimise for. As a result, they did not get to redefine the project based on what they found easier or could do faster.

In the first week of the module, students selected a project that they deemed to be a real challenge. Students were instructed to pick from a large set of projects (approx. 150) that are at a difficulty level equivalent to advanced Computer Science final year projects. They were given a metaphor of Everest and its base camps. Everest is the motivation i.e. getting to the top whereas the base camps are what is valuable to others, the 'useful outputs'. Each project had a rationale behind why it represented an area of value in the future. Students were encouraged to pick the project that would impress them if they knew someone else had completed it. They were explicitly told to avoid projects that are like anything they have done before. Generally, the projects were a good basis for research or commercialisation (such as being a potential future start-up). To add further context, the projects were grouped into areas that were promising for innovation and commercialisation. The students were also shown other 'technology areas to watch' lists from credible expert groups including MIT, Deloitte, IBM, Gartner and Bill Gates.

The project is structured around building a portfolio for yourself of the work completed. This involved the completion of several outputs that were assessed on their usefulness as well as self-evaluations for the students to understand what holds them back in terms of productivity. Each week the students completed 3 documents prior to their meeting in addition to working on their projects. The 3 documents are based on the 3 Ps approach to communication used by CEOs when communicating with their Board of Directors. The 3 Ps are Planning, Progress and Problems. The self-evaluations took the form of weekly diary entries. Week-to-week these would be reviewed with the supervisor and the students would therefore have to take accountability for their weekly work output. This would also provide the opportunity for a high bandwidth communication about any issues they were having. This intense type of feedback and evaluation leads to the development of a more personal, coaching-type relationship with the supervisor. This facilitated the students not only getting technical/ practical advice but also advice on time management and work ethic front. The diary entries also enabled work prioritisation as the student could reflect on their objectives and identify who specific work would be useful for. This frequent, formative

feedback was used to set out clear criteria for performance, encourage students to self-assess and provided the supervisor with diagnostic information about student performance. There is a pattern of experiences and emotions we expected the students to progress through. These are summarised below.

Table 1 : Stage of project and predicted student experience at that stage

Stage	Introduction	Project starting point and how to guide	Project progression	Project output
Student Impact	Fear/excitement	Decreasing fear + increasing motivation, self-efficacy/ego	Motivation, self-reflection + skill development, perseverance and stamina challenges	Quality, usefulness and humility/ grounding of ideas and impact

Students also completed assessed outputs such as an online how-to guide, a blogpost to explain and highlight their work and uploaded open source code for others to use. These assessments were designed to replicate how other high-status technically skilled individuals promote themselves online. The students were thereby awarded marks for how they approached the work, their work ethic and the value of their work outputs, not how far they got. In other words, task-oriented work was rewarded.

The first challenge was getting students to learn how to use online sources to solve a difficult technical problem, typically getting an advanced project running where existing guides had a very steep learning curve. This approach was very much focused around skill development and showcasing their learning via the development of a how-to guide at the end. This served as a good starting point for their projects as they were encouraged to create an interesting tutorial and GitHub repository. Furthermore, the how to guide acts as a lastingly valuable product, which is designed to be public and served as evidence of the difficult challenge they are overcoming. This first part of the project served ego-orientated individuals well as there was a quantifiable output that would showcase how much they learned at the end of the first assessment. The first challenge served as an excellent opportunity to begin to identify the motivations of the students on the course. In general, three types of student emerged:

Independent, motivated- those capable of taking on self-directed, big idea projects with the right support. Some may also have specific career goals especially along entrepreneurial lines. One-to-one supervisory role focused around providing some direction, maintaining end goal focus and output usefulness for broader public consumption, aid with overcoming possible brick walls and general pastoral support to maintain motivation. The aim of the module for these types of student is to better equip and guide students into entrepreneurial or research roles, possibly even producing small start-ups based on the project content.

Semi-independent, somewhat motivated- those with potential to work independently but lack the confidence or experience to think creatively and direct/ drive the project forwards. May reduce project-based work to smaller time frames and rush outputs, minimising focus on long term objectives. Again, may have a specific career in mind but may be more suited to working for

someone rather than working for themselves. The supervisory role in this context is to aid in the creative thinking process, help direct students down more creative avenues and in the development of 'the big picture'. The role may also involve building on soft skills such as more effective time management and project planning. The aim of the module is therefore to promote their independent-working skills and motivation to better prepare them for their career path, potentially even supporting development of working for a company to entrepreneurial or research work (working for themselves).

Dependent and / or minimally motivated- students are generally more dependent on specific process guidance and need a step-by-step breakdown to progress. They find it very difficult to envision long term goals or end-of-project outputs and impact/usefulness. Often they are unmotivated, tend to leave work until the last minute and are prone to procrastination. Here the supervisory role focuses on developing the student's ability to think creatively in the development and direction of their own projects as well as aiding in soft skill development. Often more basic soft skills need fostered such as working incrementally and to a schedule. The aim of the project for this type of student is to up-skill to the next level of independence. These students, by the end of the module, should be relatively capable of managing themselves and somewhat capable of driving independent project-based work in the future.

The second challenge was encouraging students to view their projects from the perspective of how others would find their work useful. In other words, the second part of the project was to refine their work to a standard where its usefulness and finish are useful to others. This encouraged students to adopt a different mindset, moving away from a showcasing/ego-motivated approach and into a practical/task-motivated approach for what the final product would look like and do. This included identifying how their work could be promoted to a community. This encouraged the students to engage with that community and view their project from the perspective of that community. Projects finished to an extremely high standard could feasibly (and ideally) be easily transitioned to form the basis of a tech start-up company.

This second phase of the project is not as favourable to ego-motivated students as it requires continuous working for what could be only marginal gains in the projects progress. They are working hard for little validation. Individuals who are more task-orientated, in other words those who like the challenge or the learning process better, are more favoured as they understand the value of completing the project well.

Running concurrently with the first and second challenge is the self-reflective diaries. Students will be able to identify their strengths and weaknesses in the context of these self-directed project modules, better equipping them for the remainder of the degree and ultimately working life. Knowing these strengths and weaknesses allows the students to work more effectively in controlling for and counteracting their weaknesses using strategies developed during the module to allow their strengths more room to grow. This also facilitates a hard look at their self-efficacy in a work context to further define what type of job role suits them best.

The third and final challenge was the submission of their project. The submission was the amalgamation of their weekly diaries (problems, progress and plan), their blogpost and how-to guide and a GitHub repository of their outputs. The final product is assessed on how well the students can see things from others' perspectives. In this regard, their final submission is non-traditional for project modules, student marks reflect how their project would be reviewed by the community/public forum to which it would be

posted. This is in some ways a stricter standard to which the outputs are held. After the submissions were assessed the students' marks were compared to their motivational style to identify any patterns or trends in performance. Additionally, reflections were made on how the course benefitted various types of student and what could be done better in any future iterations of the course. The overall success of the module was also assessed based on the quality of project outputs and the views of the students regarding the module.

Literature Review

Employability has become a key issue in the UK Higher Education sectors, particularly since the increase in student fees at British universities (Kandinko & Mawer, 2013). Employability is a set of qualifications, skills, attitudes, and personal characteristics that enable the university graduate to seek and find a job and, crucially, to be successful in it. Universities play a key role in developing employability skills of their graduates (Fallows & Steven, 2000). 'Generic' skills are high-order, transferable skills that are common to almost all complex endeavours. They include communicating, problem-solving, curiosity, patience, flexibility, purpose, persistence, resilience, courage, and creativity, and apply across all disciplines. They enable people to organize, adapt and strategically apply their specific skills to new situations and circumstances (Paadi, 2014). These are referred to as 'transferable' because they are skills that, developed in one area of life, can be transferred to other areas.

A Briefing Note from the European Centre for the Development of Vocational Training (Cedefop, 2014) reported on a study of European companies. They concluded that about 40% of companies in the EU struggled to find workers with the right skills. Many employers and policymakers argue that these difficulties are caused by the inadequate preparation of graduates and other workers. Matsouka & Mihail (2016) carried out a series of comparisons between the skills companies seek and the skills companies feel graduates have; and the skills graduates believe they possess compared to the skills companies believe they have. Regarding the skills sought and skills possessed, the areas of greatest mismatch are emotional intelligence, influence and sales skills, goal setting and professionalism. The only competencies that companies believe graduates have at a high level are academic qualifications, but these are less important to employers because they are seeking entry-level graduates. Matsouka & Mihail (2016) also demonstrated the large differences between the skills graduates believe they have, and those skills companies believe they have. Skills that are rated much higher by graduates than employers include: emotional intelligence, professionalism, goal setting, influence and sales skills, leadership skills and ethics/integrity. There is, therefore, a strong desire to increase these 'soft skills' during the graduates' time at University.

A typical approach is the introduction of a project module. UK universities normally require a final year dissertation or research project as a culminating degree experience (Parker, 2010). Their impact on undergraduate learning has been well documented, but traditionally these gains have been in final year projects (Parker, 2018). These advantages include an improvement in their knowledge, skills and personal development in areas such as problem solving, analysis, initiative and communication, tolerance for ambiguity and integrating theory and practice (McGrath, Guerin, Harte, Frearson, & Manville, 2015; Bauer & Bennett, 2008; Laursen, Hunter, Seymour, Thiry, & Melton, 2010; Lopatto, 2004, 2007, 2010). Parker (2018) evaluated the impact of undergraduate research on over 5000 students across natural and social sciences and humanities to gauge the research gain or impact on students' achievement. Parker (2018)

found that undergraduate research benefits students even more than more traditional classroom experiences, it also promotes more equitable outcomes, providing greater benefit to students with lower academic achievement than those with higher grades. Additionally, research suggests that the longer and more intensive the supervision of research, the more impact it has on students (Fechheimer, Webber, & Kleiber, 2011; Russell, Hancock, & McCullough, 2007; Taraban & Logue, 2012; Thiry & Laursen, 2011). It stands to reason therefore, that introducing this intensely independent and supervised project earlier in the student's degree could have more profound long-term benefits to their skills and employability.

What is essential in these projects is that students maintain motivation. People are motivated to develop and demonstrate competence and avoid demonstrating incompetence (Nicholls, 1989). Frum (1964) put forward the famous "Pygmalion Effect Theory", which proposes that people's level of motivation will be the greatest when they have the possibility to achieve the expected goal. This would imply that once students are stimulated by the words or behaviours of teachers in universities they will develop rapidly.

Key, therefore, to successful implementation of an independent but difficult project is the role of the supervisor, ideally an almost parental guidance and encouragement of students (Yuan, 2019). In other words, the motivational climate created by the supervisor via their words and actions and how they tend to provide feedback, evaluation, and organization (Duda, Papaioannou, Appleton, Quested, & Krommidas, 2014) can have an impact on the motivation and achievement of the students.

Task-oriented motivational climates elicit more enjoyment, satisfaction, and interest; whilst ego-oriented environments are correlated with higher levels of anxiety, avoidance or reduced effort in response to failure (Baric & Bucik, 2009; Breiger, Cumming, Smith, & Smoll, 2015; Curran, Hill, Hall, & Jowett, 2015; Duda et al., 2014). Nicholls (1989) noted that task-orientated climates involve tasks without evaluative cues, extrinsic incentives and less physiological stress. Here students will equate their ability with their level of effort. The focus of the task is generally learning, understanding and mastery. In this type of motivational climate, the person of authority provides much instruction and encouragement (Duda et al., 2014). In climates that are based around personal ability, valued skills or involve public evaluation (ego-orientated), the student evaluates ability as capacity, rivalry is encouraged, there is emphasis on being "the" best and mistakes are to be avoided at all costs (Duda et al., 2014). For instance, in sport this would reflect in the more talented athletes receiving more attention and other athletes being punished for making mistakes (Fusco, 2016). However, a student's response to these environments can be influenced by their own intrinsic motivations, whether they themselves are task or ego motivated.

Task-orientated students are driven to achieve mastery, to put in significant effort and are geared towards learning and self-improvement, they view success as making improvements and giving high effort. Ego-orientated students are motivated to demonstrate that their capabilities are superior to others. They aim to exceed the performance of others or to display equal performance with less effort, they view success as outperforming others (Duda & Treasure, 2015). What is important is that students can be high in one or both. Those with a higher task motivation are more likely to maintain motivation over a longer period of time, continually raising the bar for achievement whereas those more ego-orientated will only maintain motivation as long as praise and performance against peers is used as evaluation. The students' orientation can also dictate heir feedback seeking behaviour and their response to feedback. Ashford, Blatt, & Walle (2003) concludes that there are three reasons which trigger the occurrence of feedback seeking. First, an instrumental motive. This is the urge to obtain information as part of task accomplishment or task performance. The individual will seek feedback as they use it to elevate their

competence and goal accomplishment (VandeWalle, 2004). They will be motivated when they sense information from feedback will help them to lower uncertainty and increase the possibility of success (Whitaker & Levy, 2012). Secondly, the ego-based or ego-defence feedback seekers perceive feedback as a means of self-evaluation or self-judgement (Pebruanto, Hashim, & Hashim, 2018). This is two-sided; on the one hand, it can evaluate one's self-improvement, on the other they will avoid feedback if it interferes with their self-esteem or self-efficacy. Lastly, image-based individuals are likely to believe feedback to maintain others' impressions towards them (Pebruanto et al., 2018).

The purpose of this case study was to determine the impact of task or ego orientation on student performance and motivation maintenance over the duration of a first-year module. The projects were set to be beyond the student's current capabilities to encourage long term development. Students were given a task-orientated climate to work within. Feedback was given on a weekly basis in the form of one-to-one support from their project supervisor and they could make support requests that they feel would aid with their motivation and project attainment. Importantly, the case study allows for the examination of student's progress throughout the module, their adaptability and their own self-reflections.

Successes| Lessons Learned

Broadly, the module can be split into 4 stages; the initial project selection and the three assessment points. The students themselves can be grouped into 3 types, those that embraced the goals of the module (Type A), those that treated the module as similar to others (Type B) and those who struggled with the module challenges (Type C).

Two thirds of Type A embraced the module, proactively arranged meetings, got clarification on projects and discussed which was best for them. Others emailed their preferences in relatively quickly. Type B sought to minimise their work, focusing on obtaining a clear idea of how to complete the project before starting or by assuming that the project could be altered to a similar project they had completed for A-level. Type C generally submitted their preferences late and tended to pick meeting times at the end of the week. Students with high levels of ego and/or task motivation responded quickly and were clearly highly motivated. Other students sought to avoid the challenge of the module.

Surprisingly almost all type A and B students successfully got advanced technical work running within 3 weeks to develop their how-to guide; much faster than most typical final year projects and in many cases at a higher technical challenge. Type B and C students tended to view their work as a transaction, they would earn a certain mark for a certain amount of effort. They focused on identifying projects that would appear difficult but could be demonstrated in a relatively short amount of time. Unfortunately, some type C students lacked the drive and focus to teach themselves an unfamiliar subject. Some were open about their low work rate and others ignored feedback and presented alternative work.

High ego-motivated students liked the challenge of getting a good mark on the course and creating a piece of work shared on social media, generating respect. Those with a task-based motivation adapted even better, being motivated by the higher quality standard of doing work for others. They explained their work more thoroughly and implemented features that were valuable but required more patience and thoroughness. Students were required to focus on how their work was of value to others and this resulted in most type B students getting progressively lower marks for each assessment. Similarly, highly ego-motivated students lost motivation when the project work was more focused on usefulness than

impressiveness. For many this was the first time they had been asked to judge their work from the perspective of it being helpful for someone else. Arguably this was much more important to their future employability than the technical knowledge gained.

The blog post assessment provided the clearest distinction between the type A and type B students. Both types had successfully completed the first assessment and had 4 weeks to build and create the more original part of their project. During this time other modules' assessments had begun and the more ego and transactional type B students they felt they had invested enough in the module and so did not progress significantly. Those that followed feedback generally did well at this stage and all type A task-motivated students made significant progress, producing work that was potentially valuable to others and of a greater quantity than the other students. Two highly introverted type B students gradually became more enthused by their projects and started devoting more and focus on it adopting a more task-motivated approach. The third was the previously mentioned student who had difficulty assessing the value of their work to others. Type C students were broadly catching up during this period, in most cases they had not yet got enough core technical work running to be able to move onto the more original parts of the project. They tended to produce work that was a basic form of the first assessment. At this point none of the type C students' work would have been particularly valuable to others.

The final 4 weeks of the module coincided with the Covid-19 lockdown. Weekly meetings continued via online discussions however the lockdown had a highly disruptive effect on all type B and C students. Most did not attend online meetings and many type C students did not submit a final assessment or respond to emails. Around half of the type B students submitted some work but generally less than was completed in the 4 weeks prior to lockdown. Task-oriented type A students continued their work with no noticeable loss of productivity and remained in contact throughout. One Type A student did not attend meetings but produced a highly polished final submission. Two type A students are in the process of setting up start-up companies based on their projects and have entered a local entrepreneurship competition. All 3 of these students have continued working on their projects over the summer.

Additionally, the way in which students reacted to advice and feedback on their project work was significant. Many of the students had been very successful at school and were very independent. They typically decided for themselves or sought external validation for any feedback they received. In some cases, they deliberately challenged feedback or pursued alternative approaches in a way that could be described as contrarian. A smaller number were the reverse of this and were relatively keen to please and to have clear direct instructions that they could follow. Interestingly there was no strong connection between a student's attitude to feedback and their final mark. Similarly, there was relatively little correlation between their response to feedback and whether they were task or ego-motivated. Some highly ego-motivated individuals were very responsive to feedback and were very keen to win with coaching help. Other ego-motivated and task-based individuals openly challenged feedback both in person and in their logs and changed the direction of their projects against advice. Provided these changes were clearly motivated by a desire to create results that were more useful to others and not to reduce effort required they were not penalised, and in some cases rewarded. Both extremes of reaction to feedback were present in the highest type A students and the lowest type C students.

Scalability and Transferability

The approach is very flexible in terms of subject. Any discipline that has project-based work could be run in this way. The main limitation of the module is that it is very time intensive in terms of supervision. Because each student is working on an advanced project they need weekly, in person, supervision to address the problems they are facing and these can often require some minor research to address their queries. It works best with a module owner with significant practical experience.

It is a very interesting problem to consider how this approach to teaching could be extended to larger class sizes. The most common approach to dealing with large classes is to create a simplified step by step set of challenges common to all students. This enables students' problems to be anticipated and teaching materials produced so that students can use these instead of needing individualised support. To some extent this is at odds with the goal of having students take on unfamiliar and realistic problems that are matched to the student's interests. A lot of the lasting experience of the module comes from the uncertainty regarding the best direction for the project or how best to solve problems that arise. This may be too challenging for students that lack the safety net of a weekly personalised supervision meeting.

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Further Information

Link to Computer Science Challenges info:

https://computersciencechallengesqub.github.io/

Link to QLab Makerspace page:

https://makerspacequb.github.io/