Using contributing student pedagogy to enhance support for teamworking in computer science projects

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ABSTRACT

This paper discusses the progress made in an enhancement project completed at two Universities in the United Kingdom. It is reported that whilst teamworking is valued by employers, its inclusion is less well received by learners themselves [2,14,25]. The project is an example of contributing student pedagogy [9]. The work began as a project completed by a placement student as part of a university's' funded project [BLINDED]. The work explores learners' perceptions and experiences of teamworking before and as part of taught courses. These views have been intercalated into an evolving set of guidelines that have been used to inform further enhancements. These guidelines were written to enable learners to develop their own teamworking agreements to set out expected behaviors for working in the team. Whilst a work in progress, the approach and outcomes will be of interest to others engaged in the delivery and enhancement of student teamwork within computing related programmes and potentially other disciplines.

CCS CONCEPTS

•Social and professional topics~Professional topics~Computing education~Computing education programs~Computer science education

KEYWORDS

Contributing Student Pedagogy, Teamworking, Project

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1 What is it?

It is widely accepted that the ability to work as a team is a crucial skill for successful employment [21] and in particular in the Science, Technology, Engineering and Mathematics (STEM) workplace [20] and Computing [7]. However, employers report that graduating computing students are still under prepared in teamwork skills [17] often because computing students find these skills difficult to learn [5]. It is incumbent on Computer Science departments to prepare students effectively for the workplace by not only including opportunity for teamwork in the curriculum but also ensuring that this teamwork is most effective. Coverage of teamworking is mandated by the various professional body accreditation regimes that operate within the computing space in the United Kingdom and in other jurisdictions [3]. This paper describes an enhancement project that has been executed at two universities in the United Kingdom. The project addresses computing learners' perceptions of teamwork as part of assessed activities. The work integrates the exploration of learners' perceptions of working in groups and teams into the delivery, guidance and support of learners completing summative assessed team projects. This work is an example of Contributing Student Pedagogy [9]. The first stage in the project was completed in partnership with a summer placement student (The Third Author). This students' project involved researching learners' concerns related to Teamworking, the development and deployment of a perceptions survey and the embedding of the results into a set of guidelines. The project was initialized at one of the University's (University One) in 2017-18 to develop a shared understanding and agreement of appropriate behavior of individuals and team members in a team. A pilot survey was designed, developed, and deployed to explore learners' perceptions of assessed teamwork across the school at one university. The results of the survey and a related literature review were completed to inform the development of a team agreement and a set of guidelines for learners completing assessed teamwork. The guidelines were written to enable learners to develop their own teamworking agreements to set out expected behaviors for working in the team. In 2018-19, the guidelines and supporting workshop were deployed into several modules at the same university as a pilot to assess their effectiveness. Following discussions with a second university (University Two), the two universities collaborated on an enhanced project for 2019-20.

The guidelines were introduced in taught seminars following an initial discussion on learners' prior teamworking experience. Learners completed a survey on their experience and perceptions of teamworking as a catalyst for these discussions. The learners developed their own team agreement for each team, based on the guidelines. The cohort's responses to the survey were discussed, again at a seminar, as a way of surfacing student views and promoting a discussion regarding positives and challenges of teamworking. At the end of each module, learners were asked to

complete a second survey providing insights into how the teamwork has progressed and how it has been supported. The surveys have been ethically approved by appropriate university processes. All learners are asked to consent to the use of their responses for the further development of support mechanisms and external dissemination / publication as a question within the surveys.

2 Why are you doing it?

Computer Science learners' perceptions of teamwork have not commonly been explored. This project employs contributing student pedagogy [9] to develop and enhance the processes related to supporting computer science team projects. This enhances the support mechanisms and the understanding of the challenges faced by learners in computer science team projects. At University One, no central guidelines existed with respect to team working. At University Two, there are university level guidelines [BLINDED] and these have been helpful in promoting good practice in the support of learners completing assessed group activities. Whilst all education and teaching of teamwork has its challenges [1,8,14], there are some unique challenges related to supporting teamwork related to computing / computer science education [8,10]. As is commonly the case in the computing discipline, the teamworking in this study involved the creation of artefacts linked in some way to the software development lifecycle. This, by its nature, has differing challenges to collectively writing a report or preparing a presentation or so on.

3 Where does it fit?

At the first university the modules operated in a year-long manner. At the second university the modules were delivered in a semesterised manner with the modules all being delivered in the second semester between January and June 2020. All the modules are taught to students as part of BSc (Hons) Computer Science programmes and involve project-based learning. In brief the modules are described next. At University One, the first-year module Developing Quality Software (Dev Software) is taught to about 180 learners. The team size adopted is 6 selected by the module leader. The focus is introductory software engineering with a focus on quality. It covers basic modelling including Use Case and Class Diagrams, implementation, and testing. It is assessed through an initial requirements document, a design document, a presentation of the implemented system and an individual reflective report. At University Two, the first-year module Systems Analysis (Sys A) is taught to about 200 students. The focus is introductory software engineering, user research and basic modelling including Use Case and Class Diagrams. It is assessed by a project and related presentation. At University Two, the final year undergraduate module, Team Project and Professionalism (Team Project) which is taught to about 160 learners. This capstone provides a case study to explore professional, ethical, legal, social issues as well as to explore the commercial and security issues related to the developed prototype and its future potential commercial exploitation. It is assessed by a proposal, a practical project and an evaluative report. At University Two, in both modules, the adopted team size is 5 and learners complete a self-selected project, including live research.

4 Does it work?

Response rates to the second survey deployed at the end of each module were quite variable. For the Developing Quality Software module 41/180 learners complete the survey, for Systems Analysis 139/209 and for Team Project and Professionalism 110/164 learners. One key difference is Peer Assessment is employed at University Two, however it is not employed at University One. Table 1 provides some insights into the responses by cohorts at each university.

	Dev Software	Sys Analysis	Team Project
How effective was your team in managing the following tasks: coordination, tracking progress and group meetings?			
	Number of responses (% of respondents)		
Not well, could have worked more effectively	6 (17%)	2 (1%)	11 (10%)
Not well but was still able to work effectively	7 (20%)	11 (8%)	10 (9%)
Tasks seemed to be managed well but it was not effective	14 (39%)	20 (14%)	13 (12%)
Tasks were managed well, and it was effective	8 (22%)	104 (75%)	71 (65%)
Other	1 (3%)	2 (1%)	5 (4%)
To what extent did team members engage (e.g. attended meetings, participated in discussions, etc) in the project?			
All team members engaged equally.	5 (14%)	55 (40%)	24 (41%)
All team members were engaged, with one or two team members to a greater extent.	7 (20%)	43 (31%)	20 (18%)
Most engaged but one or two team members engagement was very limited.	16 (44%)	34 (25%)	27 (25%)
Only one or two team members were fully engaged.	6 (17%)	1 (<1%)	10 (9%)
All team members did not engage or had limited engagement.	1 (3%)	0 (0%)	0 (0%)
Other	1 (2%)	5 (3%)	8 (7%)
To what extent did team members contribute to the project deliverables?			
All team members contributed equally well.	6 (17%)	57 (41%)	50 (45%)
Team members contributed fairly, with one or two contributing to a greater extent.	15 (42%)	57 (41%)	32 (29%)
Most contributed but one or two contributed noticeably less.	7 (20%)	21 (15%)	18 (16%)
All could have contributed more.	2 (6%)	1 (0%)	0 (0%)
Other	6 (17%)	3 (2%)	10 (9%)
Do you think you would have benefited from more guidance on any of the following issues before your group project had commenced?			
Coordination and delegation of tasks	15 (42%)	26 (18%)	19 (17%)
Team discussions and meeting	7 (20%)	10 (7%)	16 (15%)
Team Roles	14 (39%)	18 (13%)	20 (18%)

Group Project Planning	16 (44%)	20 (14%)	26 (24%)
Team communication	5 (14%)	15 (11%)	17 (17%)
Other (Commonly Covid-19 related)	2 (7%)	27 (12%)	4 (4%)
Did not need more guidance	5 (14%)	82 (59%)	62 (56%)

Table 1: Survey Responses

A Chi square test for independence, suggests student engagement on task (χ^2 (10, N=263) =38.99, p<0.001) and student contribution to task (χ^2 (10, N=254) =33.02, p<0.001) are dependent on the module studied. This suggests that enhancements by module may be in order. A Chi square test for independence, suggests the extra support requested is not dependent upon the module studied at University Two ((χ^2 (5, N=331) =5.90, p=0.68). However, a Chi square test of independence. suggests the extra support requested is dependent upon the university the module is studied at ((χ^2 (5, N=391) =31.57 p<0.001). This suggests some local enhancements could be beneficial at both universities. However, the delivery of the final stages of all three modules was disrupted by a sudden move to online delivery due to Covid-19. This was a theme commonly highlighted by learners. Such challenges included: adapting to working remotely; related to access to study for themselves or a peer (technology or internet access); disruption by moving 'home'; and self, or peer illness. Several learners requested more help with version control. Some learners highlighted that the lack of working in a team in the lab impacted their progress. At University One, the implementation assessment had been released for 3 weeks when there was a move to online, whereas at University Two, the assessments had been released for 8 weeks. Equally, response rates between the modules may be a contributing factor. In University One, in the teams reporting issues with at least one member of the team, 25 out of 31 students mentioned that they had little or no engagement with the team agreement after the start of the project. For the academic year 19/20 the project associated with the module being discussed here was combined with the assessment for another module. The structure of the assessment within this second module affected the organization of the teams and may be reflected in the survey results. These delivery differences may have had an impact.

When asked if learners had "experienced or witnessed any conflicts within your group, you perceive were relating to gender, sexuality, religion, race, identity or nationality", a tiny minority reported they had. Each module had one student indicated they had conflict and not reported it. However, two students in Team Project and one student in Dev Software indicated they had reported conflicts, but it was investigated to their satisfaction. For the next delivery, the guidance for the construction of the team agreement will be updated to explicitly signpost the available mechanisms. On reflection, the survey question was too broad and may have conflated issues and hence potentially hid uncomfortable truths [2], this will be addressed for the next iteration. The guidelines, specifically the team agreement, is part of the solution as the student on Dev Software referred to this document when reporting the issue.

At both universities, the perception of the academics was that the team agreement [14] helped the formation of the teams resulting in fewer teamwork issues and most importantly more effective engagement at the start. Team agreements have been used at University Two for several years, but the guidelines strengthened the practice. The severity of the impact of the circumstances related to Covid-19 and differing response rates aside, the other main difference in practice between the two universities is the use of peer assessment at University Two. The differences in the responses from students suggests that this is effective at promoting engagement from the full team.

5 Who else has done this?

Project-based learning is not a new idea and arguably builds on early work related to experiential learning by John Dewey [4]. Developing teamworking skills is a curricula element that requires careful thought to implement to address a number of challenges including: preventing social loafing (free-riding, free-loading, passengers and related terms) and using assessment appropriately [18]; design to encourage collaboration [24]; clear individual accountability [1] and use of a learning agreement / contract [11,12,14], and differing gender behaviors [10].

Contributing student pedagogy [9] has been used to explore learners' perceptions of team assessment regimes [16,19], however how it can be used to enhance teamworking guidance and procedures has been less frequently explored.

The placement student acknowledged the influence of Daniel Levi [13] in developing the guidelines. Other sources are cited in the guidelines including work on developing a team contract [11] and managing problem behavior [22]. The student framed the work into the computing context and embedded findings from her survey to highlight key issues that the guidelines addressed.

The work is also consistent with the practical advice related to computer science project work [5] which suggests key factors may include: good group self-management (which the guidelines promote); a suitable technical level; "real" projects, (which is the case at University Two); and the willingness to gradually transfer control and responsibility for learning from tutors to learners. The use of contributing student pedagogy is evidence of this. Other suggested strategies to promote effective team working have included: redesigning the early part of delivery to incorporate team training and building [23]; advising on best practice, including team challenges and reflecting upon experience [5, 6], (although team challenges and games may neglect learners taking responsibility for participation); and use of upfront peer evaluation to better understand opportunities and obstacles [12].

6 What will you do next?

There are several avenues for further work. Firstly, given the current blended learning approach in the UK there is a need to strengthen support regarding remote working. Secondly, the teamwork guidelines will be revisited to reflect the information provided by learners at that institution. This is particularly

important for University Two to further emphasize to learners the relevance of the guidance to their place of study. Thirdly, the feedback from learners at both universities suggests that there is a need for further support in terms of handling social loafing. Unsurprisingly, given its visibility in the literature [18], learners perceptions related to social loafing remains a challenge in terms of supporting teamworking, although use of peer assessment may help. Fourthly, further work is needed to encourage teams to adapt the Team Agreement over the course of the project, so it becomes a living document. This is particularly important for longer projects where teams can lose momentum and go into decline. Fifthly, gaining a better understanding of learners' perceptions of how computer science teamwork is supported appears to be a productive area for further research. Sixthly, whilst the guidelines promote respectful and inclusive behavior, they fall short of emphasizing the benefits to productivity and innovation that diverse teams promote [15], the intention is to update the guidelines to signpost and promote these benefits. Finally, it is possible the work could be extended to include further modules at the two universities involved or at other universities.

7 Why are you telling us this?

This work has surfaced three practice recommendations. Firstly, Contributing Student Pedagogy is an approach that can be employed to better understand learners needs and challenges with respect to teamwork and thereby lead to enhanced processes. Secondly, whilst it does not fully prevent social loafing, use of peer assessment has a positive impact on team contributions. Thirdly, use of a team agreement has been found to be an effective approach to help team formative and prevent team issues particularly at the early stages of a project. Whilst this work has been completed in Computer Science these practice recommendations apply equally to other disciplines. Additionally, the sudden move to online study in response to Covid-19 presented further challenges [4], including working with students to develop good practice guidelines to support socially distanced teamworking at scale.

REFERENCES

[1] Donald Bacon, D. 2005. The effect of group projects on content-related learning. *Journal of Management Education*, 29, 248-267. https://doi.org/10.1177/1052562904263729

[2] Kalwant Bhopal and Holly Henderson. 2019. Competing inequalities: gender versus race in higher education institutions in the UK. *Educational Review* 0, 0 (2019), 1–17. https://doi.org/10.1080/00131911.2019.1642305

[3] Tom Crick, James H. Davenport, Paul Hanna, Alastair Irons, and Tom Prickett. 2020. Computer Science Degree Accreditation in the UK: A Post-Shadbolt Review Update. *In Proceedings of the 4th Conference on Computing Education Practice 2020 (CEP 2020)*. Association for Computing Machinery, New York, NY, USA, Article 6, 1–4. DOI: https://doi.org/10.1145/3372356.3372362

[4] Tom Crick, Cathryn Knight, Richard Watermeyer, and Janet Goodall. 2020. The Impact of COVID-19 and "Emergency Remote Teaching" on the UK Computer Science Education Community. *In United Kingdom & Ireland Computing Education Research conference. (UKICER '20)*. Association for Computing Machinery, New York, NY, USA, 31–37. DOI: https://doi.org/10.1145/3416465.3416472

[5] Judy Cushing, Kate Cunningham, and George Freeman. 2003. Towards best practices in software teamwork. *J. Comput. Sci. Coll.* 19, 2 (December 2003), 72–81.[4] John Dewy, 1938, Experience and Education, New York, Kappa Delta Pi

[6] Robert Drake, Geraldine Goldsmith & Rebecca Strachan. 2006. A novel approach to teaching teamwork, *Teaching in Higher Education*, 11:1, 33-46, DOI: https://doi.org/10.1080/13562510500400115

[7] Marisa Exter, Secil Caskurlu, and Todd Fernandez. 2018. Comparing Computing Professionals' Perceptions of Importance of Skills and Knowledge on the Job and Coverage in Undergraduate Experiences. *ACM Trans. Comput. Educ.* 18, 4, Article 21 (November 2018), 29 pages. DOI: https://doi.org/10.1145/3218430

[8] Sally Fincher, Marian Petre and Martyn Clark eds., 2001. *Computer science project work: principles and pragmatics*. Springer Science & Business Media.

[9] Hamer, Quintin Cutts, Jana Jackova, Andrew Luxton-Reilly, Robert McCartney, Helen Purchase, Charles Riedesel, Mara Saeli, Kate Sanders, and Judith Sheard. 2008. Contributing student pedagogy. *SIGCSE Bull.* 40, 4 (December 2008), 194–212. DOI: https://doi.org/10.1145/1473195.1473242

[10] Laura Heels and Marie Devlin. 2019. Investigating the Role Choice of Female Students in a Software Engineering Team Project. *In Proceedings of the 3rd Conference on Computing Education Practice (CEP '19)*. Association for Computing Machinery, New York, NY, USA, Article 2, 1–4. DOI: https://doi.org/10.1145/3294016.3294028

[11] Roy Herrenkohl. 2004. *Becoming a Team*. Mason, Ohio: Thompson/South-Western

[12] Edward Kapp,. 2009. Improving Student Teamwork in a Collaborative Project-Based Course. *College Teaching* 57, 3 (2009), 139-143.

[13] Daniel Levi. 2015. *Group Dynamics for Teams*. Sage Publications

[14] Barbara Maiden, and Bob Perry. 2011. Dealing with free-riders in assessed group work: Results from a study at a UK university. *Assessment & Evaluation in Higher Education*, 36, 451-464. DOI: https://doi.org/10.1080/02602930903429302

[15] Christian Østergaard, , Bamm Timmermans and Kari Kristinsson, 2011. Does a different view create something new? The effect of employee diversity on innovation. *Research Policy*, 40(3), pp.500-509.

[16] J. K. L. Poon. 2011. Students' perceptions of peer evaluation in project work. *In Proceedings of the Thirteenth Australasian Computing Education Conference - Volume 114 (ACE '11)*. Australian Computer Society, Inc., AUS, 87–94.

[17] Alex Radermacher, Gursimran Walia, and Dean Knudson. 2014. Investigating the skill gap between graduating students and industry expectations. *In Companion Proceedings of the 36th International Conference on Software Engineering (ICSE Companion 2014)*. Association for Computing Machinery, New York, NY, USA, 291–300. DOI: https://doi.org/10.1145/2591062.2591159

[18] Linda, Riebe, Antonia Girardi, and Craig Whitsed. 2016. A Systematic Literature Review of Teamwork Pedagogy in Higher Education. *Small Group Research* 47, no. 6 (December 2016): 619–64. https://doi.org/10.1177/1046496416665221.

[19] Anya Tafliovich, Andrew Petersen, and Jennifer Campbell. 2016. Evaluating Student Teams: Do Educators Know What Students Think? *In Proceedings of the 47th ACM Technical Symposium on Computing Science Education (SIGCSE '16)*. Association for Computing Machinery, New York, NY, USA, 181–186. DOI: https://doi.org/10.1145/2839509.2844647

[20] Elli Theobald, Sarah Eddy, Daniel Grunspan, Benjamin Wiggins and Alison Crowe, 2017. Student perception of group dynamics predicts individual performance: Comfort and equity matter. *PLOS ONE*, 12(7), p.e0181336.

[21] Sarah Thomas and Susan Busby. 2003. Do industry collaborative projects enhance student earning? *Education and Training*, 45: 226-35. 10.1108/00400910310478157

[22] Peter Scholtes. 1994. *The Team Handbook for Educators*. Oriel Incorporated.

[23] Michael James Scott, Alcwyn Parker, Brian McDonald, Gareth Lewis, and Edward J. Powley. 2019. Nurturing Collaboration in an Undergraduate Computing Course with Robot-themed Team Training and Team Building. *In Proceedings of the 3rd Conference on Computing Education Practice (CEP '19)*. Association for Computing Machinery, New York, NY, USA, Article 5, 1–4. DOI: https://doi.org/10.1145/3294016.3294019

[24] William M. Waite, Michele H. Jackson, Amer Diwan, and Paul M. Leonardi. 2004. Student culture vs group work in computer science. *In Proceedings of the 35th SIGCSE technical symposium on Computer science education (SIGCSE '04)*. Association for Computing Machinery, New York, NY, USA, 12–16. DOI: https://doi.org/10.1145/971300.971308

[25] Laura Wilson, Susie Ho & Rowan H. Brookes. 2018. Student perceptions of teamwork within assessment tasks in undergraduate science degrees, *Assessment & Evaluation in Higher Education*, 43:5, 786-799, DOI: https://doi.org/10.1080/02602938.2017.1409334