UNDERGRADUATE STUDENT EXPERIENCES OF PUBLISHING BIOMECHANICS RESEARCH

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The aim of this study was to investigate student experiences of publishing undergraduate research in biomechanics. Twenty-nine people with experience of publishing peer-reviewed undergraduate biomechanics research completed an online survey regarding their perceived benefits and level of involvement in aspects of the research process. On average, students perceived their experiences to be 'largely helpful' or greater in all aspects. Areas were identified corresponding to the greatest (e.g. understanding of the research process: median extremely helpful) and least (e.g. statistical analysis skills: largely helpful) perceived benefits and the greatest (e.g. reading relevant literature: I did most of the work) and least (e.g. developing hypotheses and/or methods: myself and my supervisor/others did a roughly equal share of the work) student involvement. No significant effects of level of involvement on related perceived benefits were reported ($0.319 \leq \chi^2 \leq 9.000$). Common intended learning outcomes may be achieved through involvement in the research process independently of the level of staff involvement. Such teaching strategies are especially effective in achieving broad non-technical objectives.

KEYWORDS: teaching, learning, Higher Education, supervision, dissertation

INTRODUCTION: Staff-student partnership has significant beneficial effects on many factors related to teaching and learning. These include employability skills and attributes, a deepened understanding of and contribution to the academic community, and raising the profile of research in teaching and learning (Cook-Sather et al., 2014; Jarvis et al., 2013). One common way of facilitating staff-student partnerships is through undergraduate research. Student effort in research projects is positively linked to both intent to publish and the time spent on the project by staff (Salsman et al., 2013). Literature specifically considering student experiences of working on published research is largely anecdotal (*e.g.* Giuliano et al., 2019). Such experiences are discipline-specific and no research to date has focused on experiences within biomechanics. An enhanced understanding of student experiences in publishing undergraduate biomechanics research may facilitate application of evidence-based teaching and learning strategies within the discipline. The aim of this study was therefore to investigate student experiences of publishing undergraduate research in biomechanics.

METHODS: Twenty-nine people with experience of publishing peer-reviewed undergraduate biomechanics research were recruited to participate in this study via professional and social media networks. Study details were explained to each participant and informed consent obtained in accordance with the institutional ethics committee. Each participant completed an online survey, adapted from two previous investigations (Mabrouk & Peters, 2000; Salsman et al., 2013) and composed of three sections:

Section 1: Perceived Benefits. Participants rated the perceived benefits from the published project in sixteen aspects of the research progress, selecting one of '*not at all helpful*', '*a little bit helpful*', '*moderately helpful*', '*largely helpful*', '*extremely helpful*' or '*not applicable to my project*'. Questions were: '*Has your undergraduate research been helpful in improving your: 1) Ability to work independently; 2) Ability to collaborate with other researchers; 3) Understanding of the research process; 4) Self-confidence; 5) Sense of accomplishment; 6) Interest in your field; 7) Knowledge of ethical standards; 8) Ability to locate and identify relevant literature; 9) Ability to read and understand primary literature; 10) Ability to integrate theory and practice; 11) Critical evaluation of methods in literature; 12) Ability to solve technical or procedural problems; 13) Ability to collect data according to a plan; 14) Data analysis skills; 15) Statistical analysis skills; 16) Written communication skills*'.

Section 2: Level of Involvement. Participants rated their level of involvement in eight aspects of the research progress, selecting one of '*My supervisor/others did all of the work*', '*I did a small amount of the work*', '*Myself and my supervisor/others did a roughly equal share of the work*', '*I did most of the work*', or '*I did all of the work*'. Questions were: '*Please rate your involvement on the following tasks relating to the final published work: 1) Reading relevant literature; 2) Developing hypotheses and/or methods; 3) Recruiting participant(s); 4) Collecting data; 5) Data analysis; 6) Statistical analysis; 7) Interpretation of the findings; 8) Preparing the written report*'.

Section 3: Narrative Exploration. Participants responded to five open questions about their experiences during the project. These qualitative responses were not analysed in this paper.

Data Analysis. Responses in Section 1 were scored from 1 for '*not at all helpful*' to 5 for '*extremely* helpful'. Section 2 was scored from 1 for '*My supervisor/others did all of the work*' to 5 for '*I did all of the work*'. All statistical analysis was performed in JASP (Amsterdam, Netherlands) Version 0.10, with figures generated using the vioplot package (Adler & Kelly, 2018) in R Version 3.6.2 (R Core Team, 2019). Friedman tests, with Conover's post-hoc comparisons, identified differences between survey items in perceived benefits or level of involvement. A Holm correction controlled for multiple comparisons, with a p-value < 0.05 indicating statistical significance. Kruskal-Wallis tests reported the effect of levels of involvement on related perceived benefits (*e.g.* effect of involvement in preparing the written report on perceived benefits in written communication skills). The false discovery rate was controlled for multiple comparisons via the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995) with a critical value for false discovery rate of 0.25.

RESULTS: A significant ($\chi^2 = 49.058$; df = 15; $p < 0.001$) between question effect was reported for perceived benefits (Figure 1). Benefits relating to '*understanding of the research process*' (median [interquartile range]: 5 [4.5, 5]) were perceived to be greater than those relating to '*statistical analysis skills*' (4 [3, 5]; t = 4.111; p = 0.006), '*critical evaluation of methods in literature*' (4 [3, 5]; t = 3.817; p = 0.019), and the '*ability to collaborate with other researchers*' (4 [3, 5]; t = 3.695; p = 0.029). Benefits relating to '*statistical analysis skills*' were further perceived to be less than those relating to the '*ability to work independently*' (5 [4, 5]; t = 3.747; p = 0.024) and '*sense of accomplishment*' (5 [4, 5]; t = 3.730; p = 0.026). No other significant differences in perceived benefits were reported ($0.017 \leq t \leq 3.487$; $0.063 \leq p \leq 1.000$).

A significant ($\chi^2 = 26.107$; df = 7; $p < 0.001$) between question effect was reported for level of involvement (Figure 2). Level of involvement in '*developing hypotheses and/or methods*' (3 [2.5, 4]) was lower than that in '*reading relevant literature*' (4 [3, 5]; t = 3.740; p = 0.007), '*recruiting participant(s)*' (4 [3, 5]; t = 3.269; p = 0.034), and '*data analysis*' (4 [3, 5]; t = 3.206; p = 0.041). No other significant differences in levels of involvement were reported ($0.000 \leq t \leq 2.954$; $0.088 \leq p \leq 1.000$). No significant effects were reported for level of involvement on related perceived benefits ($0.319 \leq \chi^2 \leq 9.000$; supplementary materials Table S1).

DISCUSSION: On average, students perceived their involvement in published undergraduate biomechanics research as 'largely helpful' or greater in all areas. These findings provide support for research-based teaching within biomechanics, in which the curriculum is designed around inquiry-based activities and the scope for interactions between teaching and research is deliberately exploited (Healey, 2005). Students perceived the greatest benefits in general concepts such as understanding the research process and their sense of accomplishment. They perceived the least benefits in specific research skills such as statistical analysis skills and critical evaluation of methods in the literature. This difference may relate to the often relatively narrow range of specific techniques experienced during research projects, although future analysis of the open question responses may provide more insight. Furthermore, undergraduate research appears to be more beneficial for developing independent rather than collaborative skills, likely due to the independent nature of many undergraduate projects.

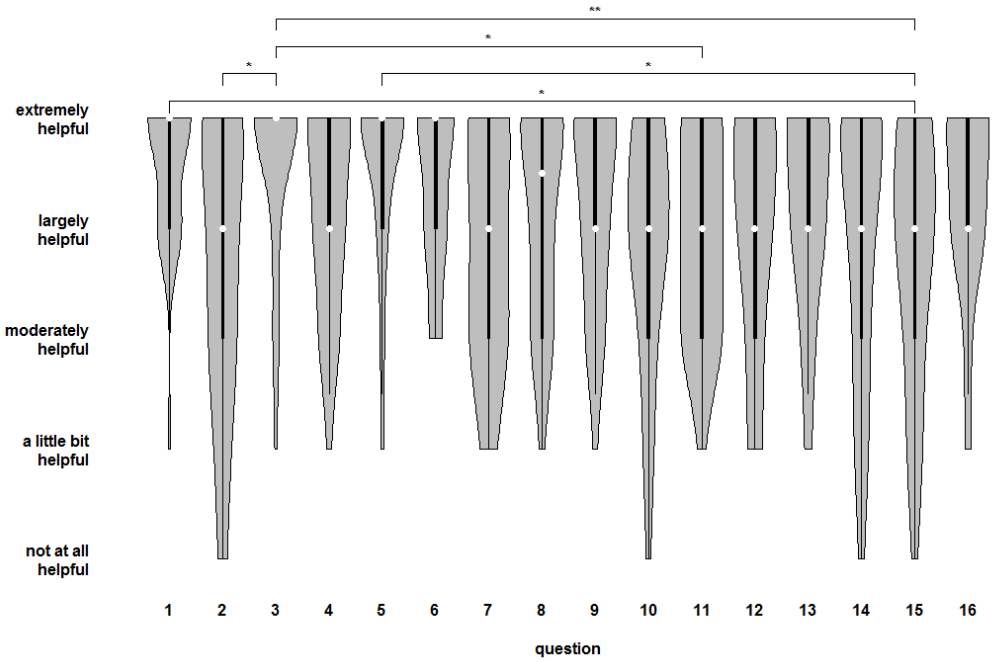

Figure 1: Participant responses to perceived benefits of involvement in published undergraduate research. White circle: median; black bar: interquartile range; grey density: frequency of each response. Individual questions are detailed in the Methods Section 1. * p < 0.05; ** p < 0.01.

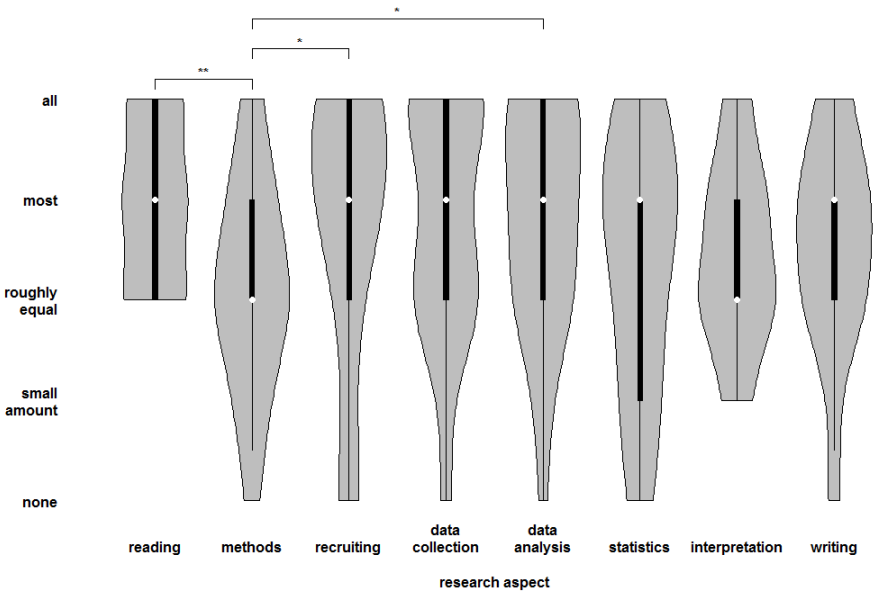

Figure 2: Participant responses to their level of involvement in aspects of published undergraduate research projects. White circle: median; black bar: interquartile range; grey density: frequency of each response. * p < 0.05; ** p < 0.01.

Students reported the greatest levels of involvement in time-consuming aspects such as reading relevant literature, recruiting participants, and analysing data. They reported the lowest levels of involvement in developing hypotheses and/or methods, a critical design stage of the research process upon subsequent stages depend. It is possible that the greater perceived benefits in broad outcomes such as sense of accomplishment rather than in specific skills relates to the greater student involvement in less technical aspects of biomechanics research. However, no significant effects were reported between involvement in specific tasks and

related perceived benefits. It must be noted that the present study has only 56% power to detect 'moderate' effect sizes at a significance level of 0.05. Participant recruitment was limited by the relatively small population size of interest (people with experience of publishing undergraduate research). A lack of significant effect should therefore not be interpreted as evidence of no effect and staff should still be encouraged to invest time and effort in teaching strategies throughout all stages of the research process. Indeed, time spent on the project by staff has previously been linked to student effort (Salsman et al., 2013).

This study has highlighted the beneficial effects of a number of Healey's (2005) seven strategies for linking research and teaching: 'giving students the opportunity to work on research projects alongside staff' within biomechanics can facilitate the achievement of common intended learning outcomes such as 'developing students' appreciation of research in the discipline' and 'developing students' research skills'. It seems that these outcomes may be achieved through involvement in the research process independently of the level of staff involvement. Staff wishing to utilise 'assignments that involve elements of research processes' or 'teaching and learning processes that simulate research processes' should make informed decisions regarding their level of involvement in each aspect of the research process based upon pedagogical principles rather than the convenience or effectiveness of student work. Curriculum design should prioritise a constructive alignment of intended learning outcomes, teaching and learning activities, and assessment (Biggs, 2003). The results of the present study suggest that involving undergraduate students in biomechanics research is one way of achieving this alignment. It is unclear to what extent these results can be generalised to wider undergraduate biomechanics cohorts. Students engaging in publishable research likely differ to those conducting typical student projects, and as such the reported perceived benefits may differ to those experienced by entire cohorts. Nonetheless, engaging students in ongoing extracurricular research projects where possible can have beneficial effects. Furthermore, there may be a survivor bias in which survey respondents are more likely to have experienced positive effects and remained in academia than those who did not respond or were not identified. With the current sample size it was not possible to control for the year the research was done or to identify trends over time.

CONCLUSION: Students reported overall positive experiences of publishing undergraduate biomechanics research, with their level of independence varying across the process. Common intended learning outcomes may be achieved through involvement in the research process independently of the level of staff involvement. Such teaching strategies are especially effective in achieving broad non-technical objectives such as an understanding of the research process, sense of accomplishment, and ability to work independently.

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