









Table 1. A summary of the challenges encountered in our multigenerational undergraduate research project on Lepidoptera and our proposed solutions to the encountered challenges. The research took place over the course of 4 years starting in 2010. The team comprised of senior and junior students attending Augustana Campus, University of Alberta in Camrose, Alberta, Canada

Challenges	Solutions
Continuing a research project with successive generations of students	<ul style="list-style-type: none"> <li>• Provide a thorough background to the project before starting</li> <li>• Develop step-by-step guides for each procedure</li> <li>• Encourage spin off projects</li> </ul>
Promoting continuity between generations	<ul style="list-style-type: none"> <li>• Encourage graduating students to complete duties much before final exams</li> <li>• All students should write in a daily research journal which is passed on with their data</li> <li>• Pair up a senior student with a junior student</li> </ul>
Involving junior students	<ul style="list-style-type: none"> <li>• Ease them into the project with simple tasks such as reading literature and informally shadowing another student</li> <li>• Ensure they can handle the responsibility</li> </ul>

research and the area of study. This may require easing a junior researcher into a project by having them shadow a senior researcher informally or simply read related journal articles until they have settled in to life as a university student (see Table 1). Not surprisingly, it has been found that the intellectual maturity of a student and their overall grade point average can greatly influence the ability to achieve project goals [9]. Therefore it is important to take extra care when considering an addition of a junior student to a research team. While junior students may be written off for lacking some of the theoretical background, they can often bring a level of passion and curiosity that is unmatched by senior students which can energize a research team. Involving junior students is also one of the best ways for addressing the challenge of continuation in multi-generational projects. A junior student paired up with a senior student becomes invaluable for the next year when that senior student has graduated (see Figure 2; Table 1). Therefore it is advised that junior students be seriously considered when recruiting student research assistants and they express interest, while using caution as mentioned previously. In the same way as junior students, students who join research outside of their field of specialization are often thrilled to try something new. Also in many ways they are in the same position as junior students who major in the research subject area. In a few words, they are new to it. It is recommended to accept only senior students from diverse academic disciplines to join research, and only if students

express interest and initiative to join research. This can usually happen when they hear about it from their classmates, roommates and friends. Due to their similarity to junior students in many respects, it is recommended to also ease them into the project and ensure they are equipped to handle the task, as mentioned before (see Table 1). Based on our experience, active recruitment of researchers outside of the discipline is not recommended. However, when “out of field” senior student joins the team, they can often bring new and valuable perspective to the research; this refreshed and unique perspective enriches it in various, sometimes unpredictable and creative ways. Adding students from other academic disciplines can also improve project outcomes, the scope of the project and the creativity of potential solutions studied in the projects. This is true as long as the students are academically successful [9].

#### 4. Conclusions

Despite to all advantages, undergraduate research can be a challenging task for all involved. It is particularly so if a goal is to generate publishable data. Multigenerational research projects provide sufficient time to accomplish this goal. However, it is crucial that consistent data collection and the continuity between generations (coupling junior and senior undergraduate researchers involved on the same project) are achieved. Detailed journals, protocols and

procedures written by students for students using practical language are essential tools in achieving the continuity and efficacy of multigenerational undergraduate research projects. In addition, diversifying the research team with junior students and students from other academic disciplines can add a level of quality, passion and creativity that can be hard to achieve otherwise. While extra care must be taken when undertaking a multi-generation undergraduate research project (especially if junior students are to be involved), the benefits experienced by both the students and the research supervisor(s) makes this approach a viable one to consider if the goal of the research is to publish. The multi-generation approach allows several generations of undergraduate researchers to contribute their efforts toward a single publishable research while each gaining valuable experience in research and in the area of study.

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## 6. References

[1] Adedokun O. A., Parker L. C., Childress A., Burgess W., Adams R., Agnew C. R., Leary J., Knapp D., Shields C., Lelievre S. and Teegarden D. (2014) 'Effects of Time on Perceived Gains from an Undergraduate Research Program', *CBE-Life Sciences Education* 13, pp. 139-148.

[2] Junge B, Quinones C, Kakietek J, Teodorescu D and Marsteller P. (2010) 'Promoting Undergraduate Interest, Preparedness, and Professional Pursuit in the Sciences: an Outcomes Evaluation of the SURE Program at Emory University', *CBE-Life Sciences Education* 9, pp. 119-132.

[3] Lopatto D. (2004) 'Survey of Undergraduate Research Experiences (SURE): First Findings', *CBE-Life Sciences Education* 3, pp. 270-277.

[4] Kaiser BN, Mishler DM, Peoples WA, and Wells AS. (2014) 'Undergraduate Research and a Liberal Arts Education: Similar Goals, Similar Solutions', *Journal of College Science Teaching* 43(5), pp. 48-54.

[5] Hunter P. (2007) 'Undergraduate research – Winning the Battle for Students' hearts and minds', *EMBO reports* 8(8), pp. 717-19.

[6] Lopatto D. (2007) 'Undergraduate Research Experiences Support Science Career Decisions and Active Learning', *CBE-Life Sciences Education* 6, pp. 297-306.

[7] Russel SH, Hancock MP and McCullough J. (2007) 'Benefits of Undergraduate Research Experience', *Science* 316, pp. 548-549.

[8] Bangera G and Brownell S. (2014) 'Course-Based Undergraduate Research Experiences can make Scientific Research more Inclusive', *CBE-Life Sciences Education* 13, pp. 602-606.

[9] Aktas CB. (2015) 'Reflections on interdisciplinary sustainability research with undergraduate students', *International Journal of Sustainability in Higher Education* 16(3), pp. 354-366.