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HOW EFFECTIVE IS REMOTE INSTRUCTION FOR ASTROPHYSICS?

Marcus Brodeur,[1] Ulrich Kolb,[1] Shailey Minocha,[2] and Nicholas Braithwaite[1]

RESUMEN

Aunque no se pone en duda el valor de los telescopios robóticos en la investigación, a menudo se asume que la enseñanza efectiva de la astronomía requiere una experiencia práctica con un instrumento físico. Hemos examinado el impacto de la percepción estudiantil sobre tecnologías de instrucción remota en proyectos de astronomía de pregrado en la Open University, en Reino Unido. Existen diferencias clave en las actitudes y resultados entre los alumnos más avanzados y los menos avanzados, pero nuestros resultados indican que los estudiantes valoran los telescopios virtuales como un entrenamiento efectivo para el control de un instrumento en vivo y que las observaciones en remoto pueden ser coordinadas efectivamente entre múltiples usuarios localizados en distintos sitios de manera coordinada.

ABSTRACT

While the value of robotic telescopes in research is hardly contested, it is often assumed that effective astronomy teaching requires hands-on experience with a physical instrument. We examined the impact of student perceptions of remote instruction technologies in undergraduate astronomy projects at The Open University, UK. Key contrasts in attitudes and outcomes exist between more and less advanced cohorts, but our findings indicate that students value virtual telescopes as effective training for live instrument control and that remote observation can be coordinated effectively among multiple simultaneous non-colocated users.

Key Words: miscellaneous — methods: statistical — sociology of astronomy — telescopes

Despite the growing sophistication of both remotely-controlled and virtualised scientific investigations, there remains significant resistance to the proposition that observational astronomy can be taught effectively at a distance from the actual instrument. Commonly-raised objections include an absence of accountability within the data pipeline itself, a lack of development of experimental and troubleshooting skills, the 'importance of screwing up' and the perils of 'menu-driven thinking' (Lockman 2005). Further concerns have been raised over the potential loss of student insight into fundamental observational techniques and instrument limitations that queued and remote observing may promote (Privon et al. 2009).

While the above criticisms can be ameliorated by training students on-site, this is not an option for a growing number of students around the world. Moreover, professional astronomers routinely control research telescopes remotely, so there exists a counterargument that acclimatizing students to off-site operation is in some ways a more valid approach. That said, as science educators we should not train students to treat instrumentation as a 'black box' from which the required data magically appears, but to fully understand the scientific principles underlying such practical work.

As detailed in papers by Brodeur et al. and by Kolb (both 2014, this volume), The Open University, UK—one of the largest distance learning institutions in the world—places a 0.43m robotic telescope at the disposal of its undergraduate astronomy students. We surveyed student cohorts at level-2 and level-3 to determine the effectiveness of two technological approaches to remote instruction in astronomy:

- *remote investigations*—where a distant real-world device is operated under remote control;
- *virtual investigations*—where computer software emulates a real-world scientific undertaking

Student perceptions were polled prior to and immediately after completion of a group work project involving the robotic telescope and clear differences emerged between the two cohorts in their pre-project attitudes. The *level-2 students* typically:

- expected to improve their subject knowledge *more* and their experimental techniques *less*;
- expressed *much greater confidence* in their ability to carry out practical science;
- felt remote work *would not be at all comparable* to on-site observation

[1]Department of Physical Sciences, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK (marcus.brodeur@open.ac.uk).

[2]Department of Computing and Communications, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK.

Post-project responses also exhibited a marked contrast of opinion, with *level-2 students* more likely to express *negative sentiments* about the experience. They were considerably more likely to *disagree* that:

- the virtual telescope had been *easy to control*;
- the live observing night had been *enjoyable*;
- *sufficient observing time* had been allotted;

Despite the aforementioned differences, both level-2 and level-3 students broadly agreed that:

- the virtual telescope *adequately prepared them* to operate the real-world telescope remotely;
- collaboration with their observing team was *easy to coordinate* (e.g., via Skype), despite the physical separation from each other and the observatory

The student response data was also analyzed using IBM SPSS Statistics 22. To establish whether dichotomous subsets of the sample—e.g., those divided solely by cohort, gender, or binary questionnaire options—showed differences in their mean assessment scores, independent-samples t-tests[3] were run against student grades. While the majority of these tests revealed no significant differences, there were two exceptions:

- those preferring *theory* to *experimentation* did consistently better both on written assignments (t = 3.683; df = 38; p = .001) and in their final course grade (t = -3.015; df = 34; p = .005);
- those reporting *prior awareness of remote experiments* performed better on their written assignments (t = -2.006; df = 62; p = .049)

The 't'-values above indicate the degree of correlation measured, 'df' denotes the number of degrees of freedom (i.e., independent cases) examined, and 'p' expresses the probability of this particular result occurring merely by chance, where the standard significance threshold of 5% or below has been applied.

To verify these findings, one-way ANOVA[4] (i.e., analysis of variance of a quantitative variable—e.g., student scores—measured against a single independent variable) were performed on categorical factors (e.g., answers to multiple choice questions).

Student responses to most questions did not reveal significant correlations, but we did observe that level-2 students who prioritized *experimentation* as a method of learning science performed more *poorly* on their written (F(3,65) = 4.150; p = .009) and interactive (F(3,65) = 3.022; p = .036) assignments. Expressing the ratio of 'between group' to 'within group' variance for the specified degrees of freedom, the 'F'-values above indicate the degree to which a correlation can be said to exist.

[3] http://goo.gl/2A1QvN
[4] http://goo.gl/0JXwDH

To determine relationships linked to the ordinal survey variables—i.e., ranked data collected via a 5-point Likert scale of 'strongly disagree' to 'strongly agree'—standard bivariate correlations[5] were applied. (Values for two standard measures—Kendall's τ-b and Spearman's ρ—were obtained and any results that were only found to be significant in one test were discarded.)

Predictably, the better-performing level-2 students felt the live observing night had been more *enjoyable*, offered a *stable* telescope connection, and led to *easily-interpreted* data (again, all at $p < .05$).

When an analogous series of tests was run on the level-3 cohort's responses, the better-performing level-3 students were found to be those who *valued*:

- *face-to-face interaction* for the project;
- *supplementary information channels* and *accurate data* for remote experiments;
- *realistic interfaces* for virtual experiments

They were also more likely to *disagree* that:

- remote experiments should prioritise *realistic interfaces* (e.g., ones that accurately reproduce the controls of the real-world instrument);
- virtual experiments should prioritise *reliable and responsive connections*;
- *experimentation* should be prioritised as a method of learning science

This study shows that practical astronomy topics can be taught effectively via wholly-remote methods and that students at different undergraduate stages can be prepared for live telescope operation via prior training only on a virtual analogue. Also, academically-stronger students assign greater value to realism over responsiveness in virtual scientific investigations, whereas a realistic interface was considered less of a priority when they were aware they were controlling an instrument remotely in real-time.

However, the above findings are derived from a restricted and self-selecting sample—participation in the survey was entirely voluntary, so only a small fraction of the students in either cohort elected to take part. Thus the trends identified above are susceptible to noise associated with small sample statistics and must be viewed as preliminary. Further work will be required with a larger sample and indeed such a follow-up study is already underway for the 2014 academic year.

REFERENCES

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[5] http://goo.gl/kxELQS