

Final Evaluation Report on Professor Les Kirkup's ALTC National Teaching Fellowship

Inquiry-oriented learning in science: Transforming practice through forging new partnerships and perspectives

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Introduction

Professor Les Kirkup asked me to be the external evaluator of his ALTC National Teaching Fellowship at the time of his nomination. Hence I have been kept informed of the progress of the Fellowship program, and have interacted with Les from the very beginning as a critical friend and an external evaluator with considerable experience of inquiry oriented learning in another discipline, particularly in first year and/or introductory courses. I also had knowledge of the work of his ALTC Associate Fellowship of 2007-2009 on *New perspectives in service teaching: tapping into the student experience*, the outcomes and findings of which contributed to the conceptions, plans and enormous drive of Les' National Teaching Fellowship – hereinafter referred to as the Fellowship.

This evaluation report provides an overview of the inspiring and remarkable achievements of Les' Fellowship with reference to the overarching goal and the issues identified by Les in planning his Fellowship. In evaluating the impact and effects of the Fellowship's activities, outcomes and deliverables, this report also emphasises how the Fellowship provides a strong foundation nationally for the way forward in transforming practice in tertiary science education consistent with the Learning and Teaching Academic Standards and Threshold Learning Outcomes for Science. Components of this foundation include

- widening and broadening of awareness and communities of practice
- identification of questions and challenges
- recognition of diversity of students, staff, institutions and scientific disciplines
- understanding of the balances required to advance HE learning and teaching in Science under practical restrictions and often conflicting forces; and
- provision of flexible and open-ended frameworks and models to foster the growth of new perspectives and to act as change agents.

This evaluation report derives from the following sources of data and information:

- The originals of the survey responses from participants in all 14 of the hands-on workshops conducted throughout the Fellowship
- The originals of the reports summarising discussion, questions, and the way forward, provided by Les to the participants of 11 of the hands-on workshops
- Analysis of the 7 students focus groups held in 5 universities; the originals were not available due to ethics arrangements with the universities

- The presentations, questions, participant and panel discussions at the National Forum, September, 2012
- Personal discussions with Fellowship stakeholders at the National Forum
- Statement from Executive Director, ACDS (attached at Appendix A)
- Les' final report
- Les' nomination and reports during the Fellowship
- My meetings with Les during his Fellowship, and the many electronic communications between us
- Resources developed during the Fellowship

The evaluative criteria used to measure the success of the Fellowship include:

1. How effective are the Fellowship outcomes and deliverables in achieving the goals of the Fellowship?
2. What kind of impact has the Fellowship had on stakeholders and the relevant national audience?
3. How has the Fellowship met the needs of participants and stakeholders and responded to developments during the Fellowship?
4. How sustainable and transferable are the approaches of the Fellowship to a variety of institutions and learning and teaching contexts?

Goals and planned outcomes of the Fellowship

The overarching goal of the Fellowship program was described by Les as the enhancement of student learning in science by effecting changes in practice through developing and embedding inquiry-oriented learning in a variety of contexts and institutions.

In planning the Fellowship program, Les outlined the intended activities and expected outcomes under three issues.

Issue 1: How can changes in practice towards inquiry-oriented approaches to learning be realised?

Expected Outcomes

- changes of practice at several Australian universities towards inquiry-oriented approaches
- the adaptation and evolution of a framework for curriculum change of value to the wider tertiary science community, and
- creating partnerships between communities of practice and enhancing networks to promote change in practice.

Issue 2: How is inquiry-oriented learning in undergraduate science experienced by the student?

Expected Outcomes

- the adaptation and extension of an existing framework for developing inquiry-oriented experiences that more effectively recognise the student experience
- supporting participant universities to assess the ways in which inquiry-oriented experiences can be better realised to maximise student engagement
- a documented analysis across three institutions of the student experience of inquiry-oriented learning.

Issue 3: How is inquiry-oriented learning facilitated?

Expected Outcomes

- creating and strengthening partnerships between communities of practice to support dissemination of successful approaches being adopted nationally and internationally to facilitate inquiry-oriented learning and the use of technologies
- increased awareness of the use of technology to support inquiry-oriented learning.

Summary of overall achievements

The challenges of these issues for lab-based Science disciplines across learning and teaching contexts and the national tertiary scene can not be under-estimated, illustrated by the number of ALTC-funded projects on these and related issues, as described in Les' final report (pp14, 15). By leading in his roles as 'innovator, broker, coordinator, facilitator and mentor' (Kirkup, 2013, p12), Les has succeeded in promoting engagement and developments, and provoking thought in a far wider community than originally expected, across all levels of students and staff, to university and discipline leaders across Australia. The outcomes and deliverables of the Fellowship as outlined in Les' final report (p8) have surpassed in scope the expectations of the planned outcomes relating to national endeavours to forge new partnerships and perspectives in transforming HE Science learning and teaching to reflect the practice of science (Chubb, 2012) and TLO3 of the Science Threshold Learning Outcomes (LTAS, 2011).

Component goals of the above overarching goal that have driven the Fellowship's achievements have included:

- facilitating transformation of practice towards inquiry-oriented approaches to learning
- playing a prominent role in shaping the national conversation on inquiry in the undergraduate science curriculum
- improved understanding of how to facilitate learning through inquiry-oriented activities, especially in large enrolment science classes
- tapping directly into the student experience to inform the design of curricula that employ inquiry-oriented approaches to learning.

Through its outcomes and deliverables and extensive dissemination, the Fellowship has furthered the aims of the Fellowship scheme and the ALTC/OLT in:

- identifying educational issues across the higher education system and to facilitate approaches to address these issues
- advancing learning and teaching in Australian higher education
- stimulating strategic change in higher education institutions
- raising the profile of learning and teaching in higher education and the prestige associated with the pursuit of excellence in teaching
- showing leadership in promoting and enhancing learning and teaching in higher education and exploring new possibilities
- establishing and building on national and international partnerships in learning and teaching in higher education
- fostering national and international collaboration and collegial networking for sharing research, innovation and good practice

- contributing to the growing community of scholars in higher education learning and teaching.

Effectiveness of Fellowship outcomes and deliverables

Each of the components of the Fellowship has been effective in its own right as well as combining to give an overall harmonious and effective program with the same overarching goal.

Workshops

The hands-on inquiry workshops delivered in 11 Australian universities (including during a HERDSA conference), 2 New Zealand universities and 1 UK university, were intended to give participants authentic experience of IOL from a student perspective, to provoke discussion and thought, and to inspire others to take IOL approaches into their institutions and courses. The evidence of their effectiveness comes from the surveys of participants, the summaries of discussion in Les' innovative feedback sheets to participants, and the requests for further workshops during and after the Fellowship.

In the surveys of participants, there was almost overwhelming agreement or strong agreement that the workshop was useful and that participants were satisfied with the teaching in the workshops. An occasional rare neutral response to one of the questions was in all cases countered by an enthusiastic response to the other. It is of interest that the only few disagree responses came from the UK university which also had some of the most enthusiastic responses, demonstrating a division of attitudes that was not evident in Australia and New Zealand. Such information in itself is very useful for tertiary leaders and developers of science curricula.

Most of the participants were staff, including some demonstrators who tended to be postgraduate students, and one workshop was for school science teachers. The comments, albeit brief, on the surveys provide strong evidence of the effectiveness of these workshops. The comments below, in response to the question 'The best aspects of the workshop for me were...', capture the main thrust of participants' reactions.

Put me in students' shoes. Food for thought.

Simplicity of presenting enquiry into scientific design.

Apply scientific thinking to a not so scientific problem.

Engagement through student freedom.

Thinking about what students want. Opportunity to discuss.

Seeing what others did.

Made me think about what I'm trying to do.

Opportunity to take ownership and play.

Engage with questions that have no predetermined answer.

More ownership for students.

Defining variables.

How to make the teaching less 'teacher-student' related, more an 'us' approach, we're both on the same side.

Suggestions for future work included more consideration of learning objectives and the scaffolding needed for such open-ended projects, more about how to design open-ended labs, and using this activity for training. The last was trialled during the Fellowship at the Fellow's home university.

Les' innovation in providing feedback to the participants summarising comments, reactions, discussion that would otherwise have no record, was very effective and should be considered by anyone conducting workshops. Much discussion centred on the challenges of assessment, criteria and appropriate non-channelling guidance for students, and the training, preparation and conduct of demonstrators/tutors. These points are discussed further below under Recommendations and the way forward.

AFFAs – Australian Fellowship Funded Activities

The innovation of a formal national program of calling for EOIs and granting seeding funds to develop IOL within applicants' home universities was effective in multiple ways. These included promotion of teaching through formal recognition and support, public furthering of the IOL agenda, advancement of national networking, mentoring of staff enthusiastic about teaching, and provision through the AFFAs' reports of vignettes of IOL development. The AFFAs also provided opportunities for participants to use aspects of the ARK (Adaptable Resource Kit) and to facilitate tapping into the student experience through student focus groups.

Because ownership of the aims, concepts and outcomes of the AFFAs lies with the participants and their universities, the nature and variety of the AFFAs provide invaluable information on how front-line teaching staff view the need for, and roles of, IOL. Most of the IOL developments were motivated by catering for a broad student base, particularly large and increasingly diverse first year cohorts with divergent interests and/or backgrounds. Comments that IOL activities engage non-mainstream students while maintaining high quality experience for discipline majors not only support the IOL approach but also provide arguments against isolationist beliefs. One AFFA was for a capstone course, and another continued the development of a series of courses vertically-integrated throughout a mainstream program. A main point that emerged in both these last two, are that the IOL approach needs to be started from the beginning, with appropriately graduated scaffolding across levels. The comment from the capstone trial was that students 'need to be more familiar with this style of self-directed learning'. Of course some States place more emphasis on this in secondary schooling than others where a heavy emphasis is still placed on central exams, so students' preparedness for inquiry will depend on the State in which they attended secondary school.

The AFFA vignettes also provide evidence that IOL can be effectively embedded through influencing the overall approach to teaching that emphasises student ownership and engagement that is not passive receiving of entertainment. This last point is of the utmost importance in preventing increasingly corruptive confusion of authentic student engagement in learning, with entertainment and/or passive reception of information, no matter how interesting or linked with current research this might be.

Resources and networks

The effectiveness of the IOL website is evidenced by its usage – approximately 1300 hits in one year from across Australia and internationally – and the comments and requests of stakeholders and audiences for examples, discussions and links. In providing a repository for workshop materials, AFFA reports, feedback reports on discussions, presentations, interviews and conversations, the website is instrumental in building a community of practice, supporting endeavours and raising the national profile of teaching and student-based pedagogy.

The effectiveness of the Adaptable Resource Kit (ARK) lies in its role as a facilitator of developments in design, trialling, evaluation and implementation of curricula, pedagogies and materials. Its own development has been informed by stakeholder experience and usage in part, and it itself has been implemented in its entirety in the design, trialling and evaluation of the solar cell IOL activity for large first year classes at the Fellow's home university.

Tapping into the student experience

The 7 student focus groups held at 5 different universities provide invaluable insight and guidance for all involved in designing curricula and supporting teaching as well as for front-line teaching staff. As described above, the AFFAs gave the opportunity to hold this variety of student focus groups within ethical restrictions. Although the originals of the students' comments are not available for ethical reasons, Les' summary provided in his final report is an excellent resource for future work and highlighting of the positives and the areas needing attention in the agenda for science education. Although it must be remembered that student focus groups are not random samples, and that, in this case, each group is reflecting on a different IOL experience, the commonalities in the feedback provide significant assistance and evidence of the effectiveness of this component of the Fellowship.

Teaching staff who are committed to their teaching, including spending time participating with students (in an 'we're on the same side' approach), listening to and observing students, are able to provide invaluable information about the student experience across the whole class, particularly when this firsthand knowledge is supported by data such as attendance, performance, student questions and responses and surveys. The AFFAs' reports include such information from across all students, and which should be placed alongside the information from the volunteer student focus groups. All of this information can be summarised by saying that the IOL approach is approved by students who value the authentic engagement through ownership, flexibility and challenge, but significant thought is needed for each level on aspects such as time, guidance, assessment criteria, teacher/demonstrator preparation and roles, and integration with knowledge development.

National forum

The effectiveness of the Fellowship National Forum on Enhancing Learning in Science through Inquiry and Technology is evidenced by registration reaching full capacity (with some late requests unable to be accommodated), by the number and quality of the presentations, by the lively discussions, and from the survey responses, including the number of comments. The responses to the closed survey questions on

p30 of Les' final report show the effectiveness of the Forum in promoting understanding and appreciation of IOL in science. The following sample of comments demonstrates some of the ways in which it was effective.

Talking to like-minded people & sharing experiences/views/learning from others/networking.

Raised level of understanding about IOL.

Stimulated me, realised I need to re-visualize current strategies & adapt to current generation of students.

Innovative presentations about the use of technology for science learning.

Knowledge of increase in resources available to support inquiry.

Learning about the variety of inquiry based activities/ideas for own teaching practice.

Keynotes & Plenaries as a rich resource as to what can be achieve; found sharing of knowledge & ideas inspiring.

Reassurance that there is a place for traditional instruction, with so many innovative possibilities to include enquiry orientated task.

Emphasis on: need for balanced approach to teaching & need for scaffolding/clear guidance when required.

Impact of Fellowship

The national impact of the Fellowship has been, and is likely to continue to be, significant and beyond normal expectations. Part of this is due to its timeliness, but it is as much due to the energy, dedication and approach of the Fellow in prioritising facilitating, mentoring, collaborating, and taking opportunities to promote a national agenda in IOL in science, perhaps sometimes ahead of some of his original plans. It also must be remembered that Les' experience and expertise in designing, developing and implementing IOL in large first year classes is based on many years of endeavour, commencing in approximately 1994. The Fellowship is a culmination of years of work and it has been expertly used by Les for maximum impact in moving IOL forward in the national science HE agenda.

The analysis above of the effectiveness of the Fellowship also indicates its impact; the aspects highlighted below provide further evidence of impact.

Engaging with senior management, discipline leaders and the science community

The Fellowship has had significant impact and on the national agenda and conversation on science HE, and has been in harmony with views expressed by the Chief Scientist (Chubb, 2012), the work of the Science Discipline Scholars and of the ACDS. This impact is evidenced by

- Les' involvement and influence in formulating TLO3 of the Science Threshold Learning Outcomes, which focuses on Inquiry and Problem Solving in Science
- Invitations to present at a number of national and international meetings, including the HERDSA conference and the ACDS Teaching and Learning Conference

- The strategic collaboration with CSIRO, with potential for further significant co-development of Australian resources for IOL activities, scalable to large first year classes
- The statement by the Executive Director, ACDS (Appendix A)

The AFFAs not only gave formal support and prominence for teaching, particularly in large first year classes, but also provided opportunities for Les to engage with senior management, extending the impact of the Fellowship, and contributing to the goal of embedding IOL in Science HE.

Invitations to contribute to discussions, developments and publications such as the Good Practice Guide on Inquiry and Problem Solving in Science, are ongoing, and indicate that the impact of the Fellowship is likely to be long-lasting.

Dissemination

Dissemination has been a core approach in this Fellowship, and one measure of the Fellowship's impact has been the extensive invitations to deliver seminars nationally and internationally. Although seminars are not directly evaluated, further invitations, including for workshops, unsolicited feedback expressing gratitude, requests for resources and visits to the website, all point to successful impact in dissemination.

National Forum

The impact of the National Forum is evidenced by comments on the participants' survey forms in response to an open-ended question 'What idea(s) do you think will have the greatest impact on your practice or institution?' Some examples are:

The value of increasing the diversity of learning methods.

Not to completely replace activities with 'inquiry'-oriented ones, but to integrate them alongside appropriate skills development.

Strategic approach-what's important to Deans-use this to convince.

Inquiry is central to science education, but must be balanced with an adequate knowledge foundation.

Rethinking first year.

Mapping the curriculum for inquiry.

The global motivation from all speakers.

Knowledge of support- not struggling on our own.

Intending to use ideas of IOL in developing next prac.

Meeting the needs of participants and stakeholders and responding to developments

Throughout his final report, Les emphasises the theme of effecting change in practice through collaboration, sharing, inclusivity and partnerships. His commitment to this has been exemplary, and the evidence of the success of this approach comes from the AFFAs, the reactions to his workshops, his work with the Science Discipline Scholars and the LTAS project, his engagement with senior management and ACDS, and his

work with CSIRO to develop scalable IOL resources linked with Australian scientific research.

As described in the final report (pp14-16), the Fellowship builds on, or links with, 6 other ALTC/OLT projects or fellowships, indicating the importance of this area in forging new directions in tertiary science education. But Les' Fellowship has gone beyond just building on and linking with, by bringing together a number of groups and networks such as ASELL, PEN, SAM-Net, he has made significant progress in the forging of new partnerships, through a judicious balance of leading and supporting. And always he has given, and continues to give, full credit to the work of others – never exploiting others by merely linking to their work. The respect in which Les is held by all who have worked or interacted with him, has been evident in all the discussions I have had with stakeholders and in the surveys and reports I have read. Holders of AFFAs and Forum participants also included comments that Les was always there for them.

It is of interest to see the comments from the UK and NZ workshops and the workshop with engineering staff in Adelaide, as members of these groups did not necessarily have prior knowledge of Les' work or of the potential of IOL in their context or discipline. That they were impressed is captured in comments such as *Seeing how much thought goes into teaching*. The Fellowship has not only met the needs of participants and stakeholders but also widened the audience for IOL.

Responding to the needs of participants and stakeholders overlaps with the ability and preparedness to respond to opportunities for new developments. This is one of the hallmarks of successful fellowships, and is indicative of fellows' roles as leaders in learning and teaching. As discussed by Les, the AFFA program and the CUUII development are major initiatives not foreseen at the start of the Fellowship, but instrumental not only in producing outstanding deliverables, but also in providing leading models for future progress.

Sustainability and transferability

The sustainability of the work of Les' Fellowship rests on the strong foundation Les brought into the program, the significant extent of the partnerships forged during the program, and his work with discipline leaders on LTAS, with the ACDS and CSIRO.

The transferability of the approach of the Fellowship is evident throughout, with proof from the AFFA program, and the development, trialling and evaluation of the organic solar cell scalable IOL activity, which takes the principles of IOL beyond the simple contexts that Les has proved to work over many years. The use of the ARK resource in this first effort of the CUUII, as well as the use of aspects of ARK in the AFFAs, demonstrates its transferability. The AFFA reports, the presentations at the National Forum, and comments from stakeholders, all attest to the transferability of Les' approach which is primarily a way of thinking about teaching, with a variety of models and exemplars, rather than a prescriptive process or a theoretical ideal. Just as IOL facilitates student ownership and self-direction in inquiry and problem-solving, with predetermined answers not necessary for development, so too is Les' approach to staff ownership in transforming practice in HE science education. For sustainability and transferability of this Fellowship, it is essential that this be recognised and allowed for by senior management in curriculum development.

Another factor in the sustainability and transferability of the work of this Fellowship is the honesty and objectivity of the reporting. All the clues are there to indicate positives, negatives, needs and cautions for future work and the ways forward in transforming practice and the implementation of the Science Threshold Learning Outcomes. These must not be ignored or swamped by beliefs no matter how well-meaning.

Factors that helped

I agree with all the factors listed by Les in his final report (p38), but also add some. Already mentioned above is the strong foundation and work of many years that Les brought to the Fellowship, and his essentially collaborative and supportive approach, leading by example while providing support, mentoring and encouragement to meet needs of stakeholders and significantly widen the national discussion and audience.

There are also a number of mentions by Les (for example, Boud et al, 1989), in his final report and in meetings and discussions with me during the Fellowship, of the ideas and inspirations he gained through participation in the Australian Learning and Teaching Fellows network, demonstrating the value of this network of Fellows for the ongoing advancement of HE learning and teaching across Australia.

Factors that hindered

My view is that Les' concerns of following 'avenues taking time away from activities approved in the nomination document' (p40 of final report) are unwarranted. One of the many strengths of the Fellowship was indeed responding to needs and opportunities, especially as Les' responses were so thorough and well-organised.

Les' comments about ethics approvals and transition challenges have been made by many of the Fellows. A number of Fellows, particularly Senior or National Fellows have attributed at least some post-fellowship transition difficulties to attitudes within their immediate home School or Department. This is an aspect of the fellowships of which senior management should be aware and take steps to prevent.

Recommendations and the way forward

As discussed in this report, Les' Fellowship brings together existing work in IOL in science, makes great strides forward in bringing new perspectives and changing practice in national HE in science, and provides a sound foundation and a model for how to progress this.

The ACDS and LTAS project should continue to consult and involve Les in policy-making.

As stated above, the outcomes and deliverables of Les' Fellowship demonstrate and emphasise that the IOL approach is a way of thinking about authentic student engagement and learning in science that reflects the way scientists work and develops desired inquiry and problem-solving skills and capabilities whether for other disciplines or for science graduates as expressed in TLO3. Hence there are as wide a variety of ways of implementing, integrating and/or embedding the IOL approach as there are institutional, course and cohort contexts.

Because of the evidence-based, objective and open conduct of all Les' Fellowship, the reports from front-line staff and student experiences and perspectives, indicate a number of ways forward, including:

- the benefits of student ownership for authentic engagement, deep learning, and enjoyment
- the benefits of IOL providing high-quality learning for diverse backgrounds and interests of large cohorts, including those of future mainstream science students in first year cohorts together with students in other disciplines
- the benefits of more enjoyment for staff activating and/or involved in IOL, including in assessment
- the opportunities for professional development of staff, including demonstrators and tutors
- the need for scaffolding appropriate for different program levels, including guidance, assessment criteria and standards, feedback and discussion
- the need for clarity, preparation and mentoring for demonstrator/tutor roles
- the need for accessible contexts whose simplicity allows genuine IOL activities. In particular, IOL must not be confused with use of research contexts or case studies with predetermined or known answers and which are essentially passing on information
- recognition that the IOL approach is inclusive of all student capabilities and interests, and prepares for all types of careers and workplaces, emphasizing student ownership of questions, and, where possible, topics and contexts. In particular, care must be taken to avoid any research links that tempt staff towards over-focus on students most likely to proceed to postgraduate research. This is a particular challenge in science education, where topics and contexts usually need to be provided, even in an IOL approach.

In addition, proponents of IOL in science HE will benefit from interaction with similar approaches in other disciplines, which may not necessarily be called IOL. For example, in Statistics, such approaches often come under the umbrella of the statistical data investigation process that reflects the way consulting and applied statisticians tackle real problems in context (MacGillivray, 1998, Forster and MacGillivray, 2010, MacGillivray and Mendoza, 2011).

Conclusion

I would like to conclude by expressing my appreciation of being involved in Les' Fellowship as an external evaluator. I have learnt a lot from Les' work and greatly value our interaction throughout the Fellowship. I believe that his Fellowship was outstandingly valuable and successful.

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Appendix A

Les Kirkup's fellowship is a landmark in the re-invigoration of tertiary teaching and learning in science. It has long been felt that science has suffered in the estimation of students because its teaching has failed reflect its character as an activity of discovery, embracing curiosity, creativity and independent thinking challenged by evidence. Many individuals have felt this keenly, tried to change their own teaching, and put forward their good ideas to other likeminded tertiary science teachers. Nevertheless mainstream science teaching has remained unaffected.

Les' fellowship has engaged the mainstream and created a national profile for inquiry oriented learning in science that provides a platform for its expansion. He has achieved this by operating at an organizational rather than an individual level, working with science faculties and their teaching and learning leaders directly, through workshops and activities that engage their own ideas and practices. It is, if you like, faculty sponsored professional development that role models the very inquiry oriented learning approach that Les is seeking to promote.

The fellowship has created a national community supporting and promoting inquiry oriented learning in science, by workshops, presentations at national conferences and by a website excellently designed to inform, engage and encourage. The success of Les' effort was made manifest by the national forum on inquiry oriented learning in science that he organized. It was well attended by people enthusiastic about the idea and pleased to share more about it. It also connected the community with respected international academics promoting similar work.

The fellowship is commendable for the breadth of ideas and approaches that it took up in the effort to promote science as a real discovery activity rather than a rarefied academic one. One notable aspect is the connection made with CSIRO. One hopes that this will continue to develop a strong connection between real world science and science teaching in universities.

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