The Evolution of Fish Detectives: From Teacher-led to Student-led in a Zoology Practical Activity

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Keywords: biology, inquiry-oriented learning, practical classes, science

International Journal of Innovation in Science and Mathematics Education, *23*(5), 79-90, 2015.

Abstract

An inquiry-oriented learning philosophy has been incrementally applied in a second year zoology practical session to transform a teacher-led dissection into a student-led experience. Traditionally, students were given a specimen and followed a detailed set of instructions on how to proceed. From 2011 to 2013, students were given a specimen and an overarching question, which gave a *reason* for undertaking the activity, and emphasised the development of the ability to use evidence to support claims. Students were provided with reduced written notes, but were still told which morphological characteristics to examine. In 2014, students were given a specimen and the same, overarching question, but no instructional notes. In small groups, students discussed which internal and external features might provide evidence to allow them to reach a supported conclusion, and how best to collect and record data. Following this discussion they reported back to the class, giving all the opportunity to modify their planned approach before beginning. End-of-activity whole class reflections on both content and process completed the circle. Voluntary paper surveys administered at the conclusion of the session explored engagement and motivation in students, and sought open comments and observations from practical demonstrating staff. Responses from students in 2014 were extremely positive. Students still benefited from substantial discussions with teaching staff, but they were now equal partners in these conversations, because many students developed approaches not previously considered by staff. Responses from practical class demonstrators described increased levels of student engagement, peer learning and interactions with teaching staff.

Introduction

Traditional (didactic) lecture and recipe-based practical class formats in university science curricula are commonly utilised and have been for decades. Some evidence suggests that these strategies can result in students developing poor learning habits, such as the passive intake of information and surface level learning (Armbruster, Patel, Johnson and Weiss 2009) without promoting student motivation and engagement (Kloser, Brownell, Chiarello and Fukami 2011; Lui and Taylor 2014). Many authors increasingly advocate for learning environments in undergraduate science which offer "learning by doing" as a more effective way for students to develop a deep approach to their learning (Healey 2005 and references therein). A student-focussed approach to learning activities embraces the established benefits which come from peer, independent and self-directed learning (Lee 2011) and increased student engagement (Creagh and Parlevliet 2014). An enhanced ability to retain and apply information, improved problem-solving and critical thinking skills, more effective group work, increased confidence, and opportunities to develop leadership and life-long learning skills (Harlen 2013) are just some of the other potential benefits of such an approach.

Inquiry-Oriented Learning (IOL) is a type of active and authentic learning, particularly popular in the context of science learning and teaching (Hmelo-Silver, Duncan and Chinn 2007; Rayner, Charlton-Robb, Thompson and Hughes 2013), in which students lead their learning by determining the approach and potentially even the question in a learning task (Lee 2011). An improvement in student attainment of learning outcomes has been attributed to the application of IOL strategies in science practical classes (Casotti, Rieser-Danner and Knabb 2008). Increasing pressure to demonstrate Australian Qualifications Framework (AQF) compliance may explain why Australia is numbered among several countries which have shown a rapid adoption of IOL teaching strategies (Lee 2012). Inquiry-oriented learning activities clearly address several of the recently developed Science Threshold Learning Outcomes (TLOs) (Jones, Yates and Kelder 2011), particularly *TLO 3 Inquiry and Problem Solving*:

> ‘3.1 gathering, synthesising and critically evaluating information from a range of sources;
> 3.2 designing and planning an investigation;
> 3.3 selecting and applying practical and/or theoretical techniques or tools in order to conduct an investigation;
> 3.4 collecting, accurately recording, interpreting and drawing conclusions from scientific data’;

and *TLO 5 Personal and Professional Responsibility*:

> ‘5.1 being independent and self-directed learners’.

These TLOs map clearly across several Bachelor level AQF criteria including *Skills* (“*will have cognitive and creative skills to exercise critical thinking and judgement in identifying and solving problems with intellectual independence*”) and *Application of Knowledge and Skills* (“*with initiative and judgement in planning, problem solving and decision making in professional practice and/or scholarship, adapt knowledge and skills in diverse contexts, with accountability and responsibility…and in collaboration with others…*”) (Australian Qualifications Framework Council 2013) and allow straightforward demonstration of compliance.

The advantages to be gained from adopting an IOL approach in university science practical classes go far beyond addressing regulatory standards, and offer a multitude of benefits to student learning. Students have the opportunity to learn from each other, to decide their own direction of exploration and to “problem-solve” their way to a solution (Kirkup 2013). Most importantly there is no single right question or set of answers, and students determine the structure of the learning task (Lee 2011). This way of learning is regarded by many as an authentic approach because it models the scientific process of posing a hypothesis, testing and critically interpreting findings (Rayner et al. 2013).

This type of inquiry adds value to face-to-face learning experiences by allowing students a safe environment in which to explore, discuss, develop valuable skills such as working effectively in groups (Armbruster et al. 2009), and express creativity and imagination: learning becomes less formal and more social, and more relevant to future employment situations (Thompson, Rayner, Barratt, Hughes and Kirkup 2014). Banchi and Bell (2008, after Herron 1971) outline four levels of inquiry under which most practical science laboratory learning and teaching activities fall. In a level one (*Confirmation Inquiry*) task, students are provided the question to be answered, the procedure or method with which to address that question, and the answer is already know, that is, students are simply demonstrating a principle. Level two (*Structured Inquiry*) describes activities in which the question and a method are provided to the student, but the direction of exploration is led by the results generated by the students. These are both considered to be relatively low level inquiry models. The third level (*Guided inquiry*) involves a question provided by a teacher, but students then develop their own method of investigation and interpretation of results. It is only at the fourth level (*Open Inquiry*), that students genuinely have the opportunity to behave like "real" scientists: both the question and the procedure are student-formulated.

Background to the study

An IOL strategy has been incrementally applied in *KZA212 Functional Biology of Animals* in the School of Biological Sciences, University of Tasmania (UTAS), to transform a basic dissection into an IOL exploration activity. Enrolments in this unit are usually between 80 and 100 students, and students are enrolled in a variety of Bachelor degree programs including Science, Natural Environment and Wilderness, Biotechnology, and Biomedical Research. Students enjoy dissection practical classes: many prefer this format above others such as moving around the room to examine selected specimens, or, understandably, researching and reporting back, or demonstrations to the class. Data collected in this unit (*KZA212*) in previous years (Figure 1), suggest that students prefer dissections and unsolicited comments from those students indicated that this was for several reasons, including 1) a preference to work at their own pace, 2) having the time and opportunity to explore something in depth, and 3) getting to view something realistic instead of text book diagrams. Students not only enjoy but also strongly value the use of animals in their learning (Edwards, Jones, Bird and Parry 2014). Dissections combine these attributes, are highly valued by students and also afford the opportunity to introduce the importance of an awareness of animal ethics issues, a valuable additional characteristic for a biology graduate. For these reasons, a dissection activity was targeted for adaptation into an IOL style activity.

In the dissection practical activity being developed, originally entitled "The functional morphology of the feeding apparatus in fish", students were each given a fish specimen. They received an extensive set of notes and diagrams, ongoing support from practical demonstrators and followed detailed written and verbal instructions on what to do, in what order to do it, how it would appear when they did, and what to think about it at the end. This was a *teacher-led* (Level One) inquiry.

This activity was subsequently modified (2011 to 2013). This occurred before the author (AE) had a real IOL framework under which to operate, and so changes were small and "intuitive", rather than being based in an educational framework. The name of the activity became "The Fish Detectives" with a view to putting the focus of action squarely on the students themselves. As before, students received an individual fish specimen and this time a framing question - "*Is your fish a carnivore, an omnivore or a herbivore, and how can you tell*?" This gave a *reason* for undertaking the activity, and emphasised the development of the ability to use evidence to support claims, further supporting an overarching theme of the unit. Students were provided with the same written notes, but diagrams were removed and displayed elsewhere around the laboratory, to be consulted as needed on an individual basis. Students were still told which features of the specimen to consider (indirectly, by the nature of the diagrams provided), but were given the opportunity to interpret characteristics and reach conclusions more independently.

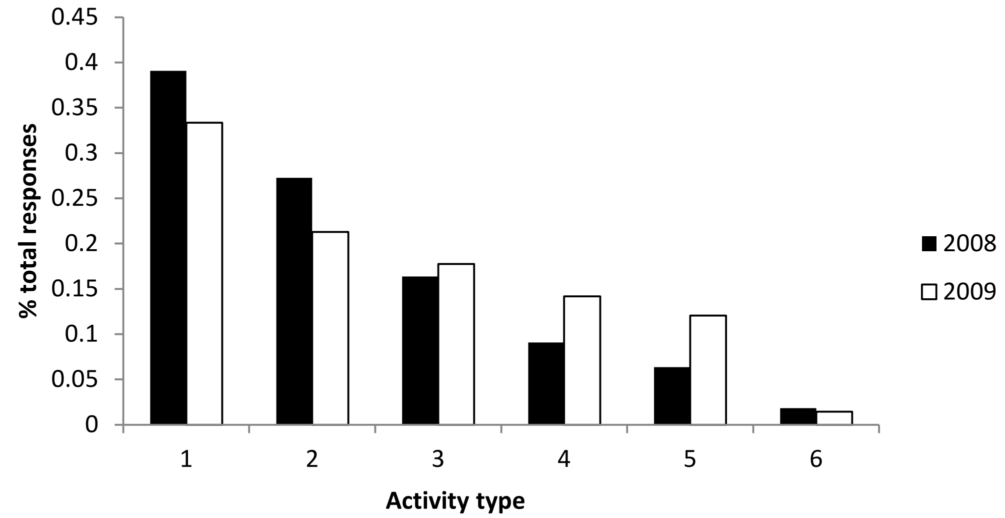

Figure 1. The proportion of students in the class in 2008 (white bars) and 2009 (black bars) who selected various types of practical classes as their preferred format. 1=individual dissection, 2=other practicals which required students to stay at "their" bench place for the afternoon, 3=moving around the room using set specimens to answer set questions, 4=moving around the room using a range of specimens to address more general concepts, 5=running one or more experiments and interpreting results, 6=other (e.g. research and report back to group, flexible practicals (attending any time during the week independent of a facilitator), or demonstrations by a facilitator)

There were a number of different fish species represented in each class, and students did not know at the outset the feeding habit of their specimen. In this scenario they were actively gathering evidence to reach and support a conclusion, and when individual features contradicted their initial expectations they were forced to consider conclusions based on a weight of evidence, and the quality of individual pieces of evidence to address the framing question. For example, do stomach contents tell accurately about the feeding habit of an animal, or only about its most recent meal? Students were supported by practical demonstrators throughout, allowing them to confirm their interpretations and build a conclusion, and were challenged to regularly reconsider their assumptions. The activity had become a type of *guided inquiry* (Level Two). In 2014, following this author's participation in a series of IOL workshops (Prof. Les Kirkup, Dr. Gerry Rayner, Dr. Chris Thompson) this practical activity was further modified with a view to reaching a level of inquiry that could be regarded as *student-led* (Level Three).

Implementation and evaluation strategies in 2014

This IOL-style practical class was undertaken in the sixth practical session of Semester 2, 2014, in a second year zoology unit (*KZA212 Functional Biology of Animals*), so that students (n=85) had time during the semester to establish relationships with bench mates. Students taking this core (prerequisite) second year unit are enrolled in a number of different degree programs including Bachelor of Science, Bachelor of Natural Environment and Wilderness Studies, Bachelor of Marine Science, as well as combined degrees and associate (two year) degrees. The class began with a short explanation from the activity leader (AE) about what IOL is, and other examples of it they had previously experienced in their time as learners at UTAS. Students had been reminded about explanations and discussions of IOL-style tasks in previous weeks leading up to this activity, and were explicitly told of the interest in knowing what they thought about the activity they were about to undertake. They were provided with the survey instrument at the *beginning* of the practical session. Practical demonstrating staff attended a training meeting in advance of the practical class as they do each week, and this time discussed delivery and support strategies in addition to content knowledge, so that all staff would be able to provide a consistent level of freedom, as well as advice and support, to the students.

Students were given an individual specimen and the same, overarching question as in the previous year, but no instructional notes or diagrams. In small groups (two to four), students discussed how they could approach the activity, which internal and external features might provide evidence to allow them to reach a supported conclusion, and how best to collect and record data. Following this discussion, they reported back to the class, giving all students the opportunity to modify their planned approach before beginning, based on sharing with peers in a non-judgemental way. End-of-activity consolidation in a whole class discussion on both content and experiences of the process completed the circle.

Before leaving the laboratory, students were invited to complete an anonymous, voluntary paper survey about their experiences and perceptions, levels of motivation and engagement with this style of learning opportunity. A five point Likert scale was applied in which 1=strongly agree, 2=agree, 3=neither agree nor disagree (neutral), 4=disagree and 5=strongly disagree. Results are presented as tabulated responses to Likert scale questions in which the proportion of students selecting agree or strongly agree have been combined, as have the proportion of students selecting disagree or strongly disagree. Students were also invited to provide open ended comments and typical responses are presented. Practical class demonstrators (n=4) were invited to reflect on how student behaviour and participation in this activity had varied from previous practical classes in the same unit. The demonstrators were asked for open comments only. Reflections from the author (AE), who was the leader of these practical activities, are also included. Information collected from students was covered by Human Research Ethics Committee approval number H0014247. A brief comparison between student results on the relevant practical test question from 2013-2014, covering the transition from the *teacher led* (Level 2) to *student led* (Level 3) style of inquiry was made using an independent t-test to detect any changes in content knowledge for material from this practical activity.

Facilitator (AE) observations of initial student discussions

During the planning time and group discussion at the start of the session, many students made copious notes, vigorously discussed their thoughts and opinions, agreed, disagreed, reconsidered and negotiated with group members about how to approach the task. Natural group leaders emerged, and those with access to the internet via phones, iPads and laptops (almost all students) shared and checked thoughts and decisions made by their group. Some students even “broke ranks” and compared their ideas with classmates in other parts of the room, examining the selection of fish specimens on other tables and factoring this into their decisions. There were a number of questions to teaching staff: these were mostly from students seeking to reassure themselves about decisions already made, for example, the best order in which to examine aspects of the specimen, rather than *what* to examine.

The room was filled with noise and energy immediately, and it was refreshingly difficult to break into these discussions for a brief time of reporting back to the whole class. During the subsequent whole class discussion before beginning the hands-on component, students either harvested ideas from others about aspects their own group had not considered, or were reassured that their own ideas were appropriate. Some approaches were challenged or questioned by others in the class, and several students formulated an evidence-based defence of their group's decisions, citing differences between fish species, and providing a logical explanation of the ideas behind a decision. Excitingly, students who did not usually interact with others during practical classes were observed actively participating in these discussions. A student captured this in the following survey comment:

> *'I'm also usually a very quiet reserved person who keeps to themselves during pracs so I really enjoyed the increased interaction with other students because I didn't feel like I was being forced to interact with them, but got lots of useful information and ideas by doing so'*

Facilitator and demonstrator observations during the activity

Students were surprisingly patient and thorough with external observations – no one simply "dived in", as they are often observed to do in other practical activities. I (AE) spoke about this with a number of groups during this phase of the activity and the responses were unanimous. All felt they were shouldering additional responsibility to get as much as they could from this activity: they had taken complete ownership of the task and did not want to miss or overlook something they might not be able to go back to later. Several students quietly admitted that they were "waiting for someone else to go first", as they were feeling "less confident" about this seeming point of no return…the first cut of the scissors or scalpel.

Practical class demonstrators reported similar experiences, and made some additional written comments after the class about how the students had embraced the activity:

> *'One thing that definitely stood out was the willingness of students to move around the room and initiate discussions with other students'*
> *'I thought there was much more relaxed engagement with the subject in this prac than in previous ones - people weren't afraid to voice their opinions and most of them were pretty spot on with their answers'*
> *'Students were thoroughly engaged with the content of the practical, more so perhaps than in a typical session'*

Likert scale survey results

The response rate for the voluntary, anonymous survey was 90.1% (73 of 81 students). The overall response from students was extremely positive, with 70% of respondents agreeing or strongly agreeing that they would like more practicals to be designed in this way. Open comments were included on 39.7% (29 of 73 responding students) of surveys. A typical comment expresses the students' general feelings about the style of the session:

> *'Yes, really enjoyed the freedom of today's prac. Definitely need more like it, it's boring just looking at notes and stuff'*

Questions designed to elicit responses about enjoyment of the practical activity and how confident the participants felt in undertaking the activity were equally positive as can be seen in Table 1. Students were generally very confident about undertaking this task, several aspects of which were novel (e.g., the taxon being dissected). A large proportion (79.4%) enjoyed the freedom to explore and 67.1% responded positively about the idea that there was no right or wrong approach. The majority of students (80.8%) commented that they enjoyed the challenges that came with this freedom. Related student open comments typically demonstrated their appreciation of the freedom of the activity:

> *'This practical was enjoyable and challenging. Being able to use alternative methods and free exploration allowed me to invest more into the practical'*
> *'I thoroughly enjoyed the ability to direct my own learning during this prac'*
> *'It is an empowering process and allows people to "shine" who may not always have that opportunity'*
> *'When I first read over the prac notes I was surprised at the lack of information provided, but when I actually took the prac I realised that this forced me to use the knowledge I already had to complete the prac …I surprised myself with how much I had actually retained from lectures and was able to put to practical use in the dissection'*
> *'…was interesting and there was less pressure …It was nice just to explore and have time to look and observe'*

However, there was a consistent message from a relatively large proportion (37.0%) of the students about a desire for more "structure" and "guidance" reflected in the survey responses to this question (Table 1). Additionally, a number of open comments (50%) expressed a desire for greater guidance. Interestingly these requests were largely for low level interventions that would have allowed the student to continue working independently, such as a labelled diagram to allow them to identify structures *in addition to* the focus of the practical class. These students were suddenly asking for ways to *increase* the content they could cover in the session, which was definitely not anticipated by teaching staff:

> *'Enjoyed the freedom and not being bogged down in reading instructions!! Would be great to have more resources around the room to refer to such as anatomy charts'*
> *'I would have liked a diagram…to be able to check identification of other organs too'*

Table 1. Student responses to questions about enjoyment and confidence after undertaking the IOL activity

Question	Agree + strongly agree (%)	Neutral (%)	Disagree + strongly disagree (%)
I was comfortable with the freedom given to me today to explore and experiment in the practical activity	79.4	5.5	15.1
The idea that there was no incorrect approach to completing the task gave me confidence to try things I might not have otherwise	67.1	15.1	17.8
I enjoyed the challenges of today's practical activity	80.8	11.0	8.2
The lack of guidance or written notes was a concern for me	37.0	17.8	45.2

Survey questions which focussed on students' perceptions of their engagement and motivation as a consequence of the IOL-style activity elicited further substantially positive responses (Table 2). The majority of students (74.0%) reported being more engaged than usual, found it easier than usual to stay focussed on the task (63.0%) and were happy to be challenged (64.4%). This enthusiasm was, however, tempered slightly by relatively fewer students confirming that they had actually changed their practice during this session with respect to revisiting difficult aspects (45.2%). Interestingly, while 64.4% of students reported that they wanted to "know more or explore further", only 35.6% believed they were actually "working harder" than in previous practical classes.

The students spoke in open comments about their increased levels of motivation and engagement, saying:

> *'…this class was liberating…This was an easier way for me to learn. Thank you!'*
> *'I really enjoyed being able to decide how to dissect my fish on my own terms, it made me feel more capable of such an activity that I usually do'*
> *'the opportunity and encouragement to ask questions, especially throughout the learning/experiencing time is my favourite and most efficient way of learning'*
> *'The independence provided for differing dynamics of motivation... I am sure future students would be happy to see more pracs like this'*
> *'It … models the scientific process … You can end up making a series of hypotheses and test them as you go along'*

Table 2: Student responses to questions about enjoyment and confidence after undertaking the IOL activity

Question	Agree + strongly agree (%)	Neutral (%)	Disagree + strongly disagree (%)
This activity was interesting and held my attention more than other practical activities I have done in this unit	74.0	15.0	10.0
I found it easier to stay focussed and concentrate on the task today than I usually do in other practical classes	63.0	26.0	11.0
I found myself wanting to know more or explore further in this practical class than I usually do in other practical classes	64.4	24.7	10.9
I went back over things I didn't understand more carefully than I usually do	45.2	41.1	13.7
I did not skip over the difficult parts, but was motivated to work through the challenges	64.4	24.7	10.9
I worked harder in this practical class than I usually do	35.6	48.0	16.4

Students were also surveyed about opportunities to make connections during this practical activity, with respect to both peer-peer interactions and in linking practical experiences to the theoretical content provided in lectures (Table 3). A large proportion of students confirmed that they believed they had not only interacted more with their peers during this session (72.6%), but that these interactions had been more helpful to them than those of previous practical activities (68.5%). Furthermore, 61.6% of students responded that they were better able to make links between hands-on experiences and existing theoretical knowledge than in more traditional style practical classes already undertaken.

> *'…the prac encouraged interacting with other students. Sometimes I find this a bit daunting but I found it really easy to talk and compare notes with other students in this prac as we were all working towards a common goal'*
> *'The format of this prac was enticing to student discussion and sharing information, which seemingly benefitted most students'*
> *'Information between students was very welcome as I got the chance to use my knowledge'*
> *'[I liked] the interaction and fellowship between students'*

Table 3: Student responses to questions about making connections while undertaking the IOL activity

Question	Agree + strongly agree (%)	Neutral (%)	Disagree + strongly disagree (%)
I talked more with other students today than I usually do	72.6	11.0	16.4
I gained helpful information from other students in the class today more than I usually do	68.5	17.8	13.7
I could see where this material fits in with what I already know better than I usually can	61.6	20.5	17.8

Evaluation of content knowledge

Importantly and reassuringly to the author, there was no decline in content knowledge gained by the students as a consequence of the change in delivery style of the practical session (independent t test: $t = -1.536$, $df = 114$, $p = 0.127$). The mean mark for the relevant practical test question in 2013 was 4.8 out of 7 (± 1.3) (68.4%), and following the transition to the IOL delivery style the mean mark for the equivalent question was 5.5 out of 8 (± 1.7) (69.2%).

Reflections after implementation

I present here the incremental development of a recipe-based, low level inquiry biology practical task into a student-led guided inquiry style learning opportunity. This was an uplifting and rejuvenating experience for teaching staff, as students, unrestricted by expectation and convention, developed new and unexpected ways to examine their specimen and collect data. Evaluation of both student and practical class demonstrator perceptions of the effect of this new mode of delivery indicated an overall positive reception from undergraduate students. Many students appreciated the freedom to be creative, and the safety of the "no wrong answer" approach. Students still benefited from substantial discussions with teaching staff, but they were now equal partners in these conversations, as quite often the opportunity to be imaginative and creative allowed students to develop approaches not previously considered by teaching staff. Beyond dissection practicals, modification of existing teacher-led tasks to student-led inquiry style activities could by very successful for recipe-based experiments, explorations of diversity, or for demonstrating and understanding relationships between structure and function. Recent research highlights success in adapting physics (Creagh and Parlevliet 2014), biology (Liu and Taylor 2014) and combinations of these with chemistry (Rayner et al. 2013) activities for IOL delivery. It is, however, worth observing that not all types of practical activities are amenable to "conversion" to the IOL style of delivery. A recently released Good Practice Guide included only one biology case study (it did not utilise vertebrate animals and so did not require ethics approval) out of seven examples (Thompson et al. 2014). The need for formal animal ethics approval in advance of some biology activities may make it difficult to offer freedom of inquiry. Inquiry-oriented learning activities are simply an exciting edition to an instructor's toolbox of teaching strategies. When undertaken effectively they are definitely worth the time and effort taken to plan and prepare, and offer opportunities for all involved to be inventive, creative and engaged.

Key observations for instructors

1) Change of mindset

A genuine shift in thinking about learning and teaching was required. I had to be brave enough to relinquish control of the learning task and trust that my students would *want* to explore, examine and interpret their specimen and participate fully in the activity. The biggest challenge was to get past the perceived inequity – what if some students did not observe a particular feature or gain some individual fact? Was it fair if students did not all have an identical set of experiences, even if they were "equivalent"? Lee (2011) suggests that part of the reason for these feelings, and the hesitation they cause is that there is no single model, formula or set of instructions for designing and undertaking IOL style activities. I was forced to carefully reflect on exactly what skills and content knowledge I wanted my students to gain. I wanted them to gain content knowledge, achieve a high level of interest, engagement and motivation, and to perceive value in peer learning opportunities. Survey results presented here and evaluation of content knowledge at the conclusion of semester indicated that the "leap of faith" was justified. Flow-on benefits in subsequent weekly practical activities included a more relaxed feeling in class and unsolicited verbal comments from students about feelings of increased confidence in their own skills and knowledge.

2) Reconsideration of assessment practices

A recent review of the assessment literature highlighted challenges in the design of summative assessment tasks which assess higher level cognitive skills in addition to content knowledge (Bird 2014). I was initially expecting that I would be unable to formally assess the IOL-modified activity in this first delivery, due to the potential for students to have different experiences and cover different content during the session. What I found was that not only did all students gain relevant experience in planning, working as a team, peer and self-directed learning *and* conducting a dissection activity, but that they embraced the opportunity to explore the discipline-specific content, and if anything, were more thorough and conscientious about exploring relationships between structure and function, about making links to lecture material and about following through on tangential features and observations after they had addressed the main focus of the activity. There were more than enough similar experiences from which discipline-specific content could be assessed. For example, a question such as "*Describe [any] 6 factors which would allow you to determine the dietary habit of a fish*" (out of a possible 10 or more) allowed all students to draw on their varied experiences and observations during the activity, and still display both content knowledge *and* reasoning/interpretation skills. However, some of the goals of IOL (e.g. participating in planning the investigation, comparing findings to initial predictions) may actually be better assessed by alternative means. I now aim to become more "assessment literate" to allow students to get the most out of IOL activities. For example, incorporation of student (formative) self- and peer-assessment can, for example, aid students in developing their understanding of what is involved in learning (Harlen 2013).

3) Scaffolded support of students

The perception that IOL-style activities require less input from teaching staff during the activity is incorrect: Inquiry-oriented activities can be challenging and time consuming to develop *and* deliver (Casoti, Rieser-Danner and Knabb 2008). I discovered that there is still an absolutely vital role for teaching staff during this form of practical activity. This came in the form of asking challenging questions, being available to provide reassurance about decisions made and strategies selected, and providing factual confirmation on content knowledge as necessary. Hmelo-Silver et al. (2007) advocate timely intervention and support strategies such as the "mini-lecture", delivered at a carefully considered stage during an IOL session so as to be most beneficial. In contrast, Liu and Charlotte (2014) describe how a "productive failure" based approach encourages students to critically review assumptions and interpretations instead of seeking the "right answer". Regardless of the specific strategy, these authors all advocate the importance of carefully aligning assessment tasks with learning outcomes to achieve learners who graduate with the ability to tackle the open-ended, undefined problems they will face in future employment situations. In the IOL practical activity described here, students were offered one-on-one and group level support throughout the activity as usual, but additional support in the form of whole-of-class discussions in the early planning stages, and again to consolidate at the conclusion of the session. In response to student requests for ways to gain additional content knowledge during the dissection, I will explore ways to achieve this without reverting to a "teacher-led" setting. Further, preparation and support of students are required, not only during IOL session, but in advance, and a more formal introductory session in a prior class session will be considered for future deliveries of this activity. Students require a scaffolded introduction to IOL in order to maximise learning outcomes (Banchi and Bell 2008).

Acknowledgements

This study was conducted under University of Tasmanian Human research Ethics Committee approval number H0014247. Thank you to Drs Fiona Bird and Tina Acuna for comments on an earlier draft of this manuscript, to practical demonstrators for engaging with the process and to the students for their feedback and comments.

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