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Interdisciplinary interactions within a small scale research initiative investigating animation creation as a means of teaching and learning

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Special Issue: Adoption, Adaption, and Integration: Renegotiating the Identity of Educational Research through Interdisciplinarity

Title: Interdisciplinary interactions within a small scale research initiative investigating animation creation as a means of teaching and learning

Abstract

This paper reports an interdisciplinary research initiative conducted by two lecturers from different university faculties who found they shared an interest in using animations to support teaching and learning. The research comprised an exploratory pilot to test the feasibility, and to explore the impact on learning, of having undergraduates create stop-motion animations of the anatomy of the developing embryo. Whilst this challenge meets definitions of interdisciplinary research, in that there was a problem of mutual concern and a systematic investigation into that problem, it may be argued that such small team could evidence only narrow interdisciplinarity. However, the two researchers' views, informed by their different disciplinary experience of research, were very different. This impacted on decisions about how to conduct educational research and their feelings about the authenticity of the different methods proposed. The two researchers' reflections on this initiative show how their perspectives changed over time. It is questionable though whether true interdisciplinary integration was achieved and we conclude that a more helpful approach is to focus on the notion of 'researcher as bricoleur', with each research team member selecting, contributing and repurposing relevant knowledge and experience.

Keywords: interdisciplinary, multidisciplinary, bricolage, animation, embryology

1. Introduction

This paper reports on an interdisciplinary research initiative triggered by a chance encounter where two university lecturers discovered they shared an interest in using animations to support teaching and learning. The two colleagues worked in different faculties however, shared a subject background in that both worked in disciplines allied to science, one in science education and the other in medical science. They were challenged by the idea of working together to explore whether making simple stop-motion animations would benefit undergraduates studying developmental processes in anatomy and hopeful that collaboration between their two disciplines would facilitate the development of creative approaches (Reich & Reich, 2006) to teaching. Thus the definition of interdisciplinarity presented by Qin, Lancaster and Allen (1997) in their early exploration of the types and levels of collaboration in interdisciplinary research (IDR) in the sciences, with its emphasis on problem solving, resonated with them. Consequently, for the purposes of the present study, IDR is defined as the integration of disciplines within a research environment that comprises a common problem-solving purpose i.e. following an instrumental as opposed to a critical form of interdisciplinarity (Repko & Szostak, 2017).

As for the two disciplines themselves, Reich & Reich's (2006) depiction of the nature of disciplines, with their distinct cultural values, norms, processes, world-views, and methods of communication aligns well with our experience. However, in the case of particularly complex, even wicked, problems transdisciplinary approaches are currently being advocated (Krasny, Oshry and Ferguson, 2016). That is research initiatives which go beyond interdisciplinary collaboration across academic disciplines to include different sectors of society such as government, private industry and third sector stakeholders. Gibbons et al. (1994) had originally introduced transdisciplinary research as having four distinct features:

- it develops an evolving framework that guides problem solving efforts that is generated and sustained within the context of application;
- it develops its own distinct theoretical structures, research methods and modes of practice;
- the results are communicated to those who have participated in the course of that participation and
- it is dynamic driven by the needs of its context.

That said though, their second point is somewhat oxymoronic, as Jacobs (2014) points out, a focus on distinctiveness would soon lead to a new discipline. More helpfully, Jahn, Bergmann & Keil (2012) model how interdisciplinarity and transdisciplinarity relate to each other noting that, "while transdisciplinarity sets the frame for a research dynamic that couples societal and scientific progress, interdisciplinarity is the science driven process of generating the new knowledge that fuels this progress" (Jahn, Bergmann & Keil, 2012, p.5).

Clearly application and action underpin this notion of transdisciplinarity in research which Zierhofer and Burger (2007) conceptualise as 'knowledge for action' and which can be integrated from different disciplines in three ways. The first is thematic integration, the systematic ordering of knowledge, the second is problem or product oriented integration and the third is social integration referring to the knowledge of the various social actors involved. In this instance the specific problem intended to generate new knowledge for action was to identify whether having university students create animations could be used effectively as a means of teaching the anatomy of embryological development. Whilst this challenge also meets Bruhn's (2000) definition of interdisciplinary research, in that there was a problem of mutual concern and a systematic investigation into that problem, it may be argued that such a

project could evidence only narrow interdisciplinarity (Klein, 2010) as the two researchers shared both extensive university teaching experience, an early background in science and an interest in teaching how the body works. Yet, as will be detailed in the following sections, the researchers' personal views, informed by their different experiences of research techniques, as to what constitutes educational research itself, how to conduct research into one's teaching practice and the authenticity of so doing were very different. Using Jahn et al.'s (2012) 'interdisciplinarity as fuel' metaphor, we explore if and how our fuel was contaminated at source.

The report presented here breaks from the traditional research project reporting format and gives an account of the first stages of the initiative from conception to completed pilot annotated with each researcher's voice. Reflections on these annotations are then used to problematize issues stemming from different disciplinary characteristics that emerged during what turned out to be an unexpectedly complex process. Thus our aim is to use narrative inquiry techniques to inform the development of new ways of thinking about the process of achieving interdisciplinary research.

2. Background to and Context for the Study

The Team

The two colleagues involved were GW who teaches Anatomy in a faculty teaching health related sciences (FHRS) and JW who teaches Education in a faculty that focuses on teaching social sciences (FSS).

GW is a Senior Lecturer in Anatomy with over 25 years' experience of teaching anatomy in higher education at undergraduate and postgraduate levels. He has often felt the frustrations of teaching anatomy, a three-dimensional topic, using two dimensional teaching materials and noted that similar frustrations are expressed by both colleagues and students in teaching and learning respectively. GW also has an extensive background of published laboratory based research in endocrinology and metabolism, employing animal models of human disease. This research is entirely hypothesis driven, with readily measured end points and employs control groups, allowing for close control of experimental variables and of methods of objective measurements of outcomes. He was keenly aware that this bias towards tightly controlled research impacted on his ability to investigate the process of learning anatomy/embryology.

JW is a Senior Lecturer in Education with experience of teaching in both schools and, in higher education, at undergraduate and postgraduate levels. She started her career studying psychology which involved working with children in schools and led to her training as a science teacher. Her extensive experience of research in educational contexts ranges from large scale surveys of hundreds of schools or evaluations of online teaching initiatives to small scale, single classroom based studies of teaching interventions. She does not associate herself with any one particular research paradigm following more of an eclectic approach as dictated by the current project's circumstances. She does however, believe strongly in a phased approach to research that allows for piloting, participant voice and multiple sources for data collection to ensure reliability.

Thus the education lecturer's research experience stems from work with learners in schools whereas the anatomy lecturer's experience of research was based in laboratory work.

The Location for the Research

This research was conducted in a city based university in the South West of England where Anatomy teaching was located close to another FHRS building and the city hospital some 500m from the School of Education. Each meeting involved negotiating entry to one or to the other's department usually via staffed reception desks at its entrance.

The pilot research itself took place in an FHRS seminar room which could be set up with tables for two groups to use to make animations and which was separated by a partition into two areas, one for each student group. The participating students were familiar with the room and with the tools; their own iPads and iPhones and Plasticine® but not the app used, iMotionHD.

The Methodological Approach

The following sections describe a case study of the interactions between the two lecturers that took place over the 16 months that it took to create and implement the pilot of a research project investigating teaching embryology through animation creation. The case study approach has been chosen as it enables an in-depth analysis of the phenomena under consideration and is also ideal for researchers who wish to investigate dynamic interactions among people (Cohen, Manion & Morrison, 2011). In particular the following case study (Section 3) with its emphasis on opportunities for participant reflection forms an epistemological, narrative enquiry exploring and reporting on our lived experiences (Bignold & Su, 2013) during this initiative. It comprises an account of events presented in the traditional form for a report of an empirical research study and, as during these events, the researchers both noted differences in their approach stemming from their disciplinary background they were later invited to reflect on this differences. These reflections have been added to the original report, as shown below, in order to evidence how they understood the developments occurring during this interdisciplinary collaboration for research.

3. The Proposed Animation Project

The research project itself was conceived as an exploratory pilot project to test the feasibility of, and explore the impact on learning of, having undergraduate students create stop-motion animations of dynamic, developmental processes in the embryo. Our initial suggestions for topics in embryogenesis to be animated included fertilisation, gastrulation, neurulation, heart septation and embryo folding as these are known to be challenging for anatomy lecturers to represent and for students to grasp. It was initiated following GW's learning of the success of JW's previous explorations with younger students who reported that they found using stop-motion animation with Plasticine® modelling clay both enjoyable and effective in supporting their science learning (Wishart, 2016). This technique is often called 'claymation' or even 'Slowmation' because playing the animation slowly allows students to record a voiceover that explains the underpinning science (Hoban, 2005). GW felt intuitively that animations of changing processes in the embryo may better explain those processes than any verbal or 2-dimensional descriptions. The research questions were:

- Can key embryo developmental processes be successfully animated by undergraduates using 'claymation'?
- What learning outcomes can result from using stop-motion animation tasks in embryology teaching?
- What are students' attitudes towards learning in this way?

Research Design

The participants for this project were volunteers from the annual cohort of first-year anatomy students from the medical veterinary science faculty who are required to complete a taught unit on embryology. A phenomenological approach to research for the project was proposed by the education lecturer focusing on capturing the students’ perceptions of teaching and learning in this way. The associated data collection would comprise qualitative methods such as observation and interview.

GW: Despite having attended workshops on qualitative research techniques, it was difficult to think away from the conventional lines of research that I had been involved with over the past 30 years involving control groups, and readily measured objectively determined end points. It was like doing research for the very first time with all the uncertainties of even the basics such as how to design a qualitative study, how to recruit subjects, how to approach the institution for ethical approvals, the new jargon, an alien background literature, what ‘end-points’ were to be measured etc. and so I sought a mentor experienced in educational research. Even then, it took a tremendous leap of faith to follow what was recommended, so alien was it to my experience and the research training I had received as a lab scientist.

Originally it was proposed that data collection would involve simply video and audio recording the students working (with their permission) on their animations to capture their discussions to identify any key learning outcomes and barriers to understanding when learning in this way and secondly, a short post-session interview. The recorded dialogue and actions captured on these videos would be thematically analysed following the stages given by Braun and Clarke (2006) to identify salient and reoccurring themes relevant to answering the research questions. However, following the dialogue described under ‘Research Permissions’ below, a pre-test and post-test for assessment of student learning was also included.

JW: This late decision was informed by dialogue with GW and another colleague in FHRs during which I realised including a quantitative assessment would both benefit the research and reassure the project stakeholders.

GW: I felt that the misapprehensions and lack of understanding of qualitative research that I suffered from were also displayed by those from whom we were seeking permission to pursue the study.

The test added comprised 14 multiple choice questions of which seven were relevant to the topics to be animated and seven were on other related areas of embryology, devised to act as a control. Participating students were also asked to rate how confident they felt about their answer using a scale from 1 (little or none) to 5 (a lot).

Research Permissions

Conscious of the British Educational Research Association (BERA, 2011) guidelines which emphasise the researcher’s responsibility towards the sponsor of any research including those that facilitate it by allowing and enabling access to data and participants, the education lecturer initiated discussion about seeking permissions for the research to take place. She sent the original, outline proposal, agreed with the anatomy lecturer to a FHRs colleague.

JW: This triggered a series of questions about the planned research design. These included:

- *How will a control group who do not make animations be organised and managed?*

- *How will a large enough number of participants to populate both experimental and control groups be secured?*
- *How will the learning of the two different groups be formally tested?*

GW: I had great sympathy with these reservations, but placed my faith in the experience of JW, an expert in a complementary but very different discipline from mine.

JW: I understood that our project was not initially viewed as viable, it lacked a control group and thus was not perceived to be a valid approach. I was surprised by this view of research as comprising a single format, my own understanding being that a researcher selects from a range of possible research designs according to context and research question being addressed.

GW: I felt the same way about this. I believe that those whose permission was needed, quite naturally, did not fully appreciate the role or nature of qualitative research, being academics experienced in the same traditional controlled and lab-based research as myself.

JW: Meetings with key personnel were then arranged to explain how the envisaged staged approach through piloting with volunteers outside the taught programme had been set up in order to first test viability of making animations as a teaching method before introducing it to large groups. The proposal itself was rewritten outlining the role of qualitative data in answering the research questions, including an explanation of thematic analysis and adding a pre- and post- test to assess student learning.

After this rewriting and further discussion the potential value of such a project was acknowledged and consent given for it to go ahead.

Research Ethics

One immediate decision that resulted was over which route to follow in order to secure formal ethical approval.

GW: Each Faculty had its own ethics committee for the conduct of research projects and because the students belonged in the FHRS whereas the research fitted into the research of the SoE we had the choice of using the ethical committee in the FHRS or its equivalent in the SoE. The ethical committee and researchers of the latter was chosen because we imagined they would be more experienced with the methods to be employed than that of the former. Additionally, attempts to gain views on the proposal in the FHRS were potentially fraught with delays due to the need to explain the methods to those unfamiliar with the proposal's methods and design.

Therefore the proposed project was steered through the School of Education's ethical review process which is designed to be both supportive and educative and involves a discussion, stimulated by prompts derived from the British Educational Research Association (BERA)'s guidelines (BERA, 2011), of ethical aspects of the proposed research project with a fellow researcher.

The researchers undertook to work with the FHRS teaching teams to ensure that the animation creation sessions were not scheduled at a time that would inconvenience their students. Prospective volunteers were briefed both about the project's aims, how data will be captured and stored and the form of any potential publications before their consent to participation was sought. That briefing included reassurance that their decision whether to participate or not will not affect their working relationship with their course tutors.

Participants were assured they could withdraw from the project at any point and, in all cases, their anonymity would be preserved. There were no known safety issues. Participants' data comprising the recordings of students' discussions and the animations they make was anonymised on storage and kept on a secure server. Images or video of the students' work were shared on the project website only with their permission.

Implementation of the Pilot

The pilot went ahead on an afternoon towards the end of the semester when the prospective participants had no scheduled lectures or other taught course commitments in the pre-examination period. It involved the students spending a couple of hours in their groups using their own iPhones and a loaned iPad and Plasticine® to make a stop-motion animation. Each group comprised a pair of students. Both groups chose to model very early embryo developmental processes, with one focusing on neurulation (the folding of cell layers that results in the formation of the neural tube, which gives rise to both the spinal cord and the brain) and the other, gastrulation (initial formation of the three cell layers). The groups worked on tables in a FHRS teaching space provided with internet access via wi-fi to use to research their ideas. At the end of the session the animations made were presented to both groups and teaching points discussed.

Whilst more students volunteered (9) than actually turned up to participate in the pilot (4), in the end, two pairs, one of men and one of women, completed animations. Both groups were interviewed together with their partner immediately following the session.

JW: I was very surprised by this drop-out rate however GW explained it was characteristic of FHRS students whose commitment, as he saw it, was overwhelmingly to their assessed work and who would drop out of other commitments if they weren't comfortably on top of this.

GW: Also, participation is also dependent on the timing; if no teaching is occurring that day, then students who signed up may decide at the last moment that it is not worthwhile to attend the animation session as it would be a major disruption to leave home to go to the university building just for a short appointment. Conversely, if the animation session had been held on a teaching day, there would have been difficulties fitting it in.

Outcomes

Both groups successfully created an animation though, that said, we should note that the animations made were rudimentary using Plasticine® and drawings in two dimensions to model key developmental changes in the very early embryo. One, with 18 frames, modelled gastrulation and the other, with 32 frames, neurulation.

GW. The animations made were crude, and at first disappointed me, but then I reflected that they were no more crude than the models I used to describe the topic in lectures, and would be immediately effective and useful in lectures. The animations could be more effective than my current models so would be an improvement over my existing teaching. Also, this was a first step and I expected crude results, looking to see whether we were on the right track that animations could be helpful. A more professional result would come from using more time, better resources (plasticine), limiting the topic to be animated, giving some training in claymation, and would depend on the individual ability of the student animators both in embryology and in animating. If these resources could be invested, then the results would not only be more useful in lecturing but also would form an online open resource for peer to peer learning. I was concerned though about the time it took to make even simple animations.

JW: The rudimentary nature of these simple 'claymation' animations did not concern me. My earlier work (Wishart, 2016) had shown that students considered the associated discussions using key science vocabulary necessary to successfully build a model and animate it to be the aspect of animation creation that was most helpful to learning. Thus my perspective emphasised the process of creation and the learning discussions involved over the final product.

The anatomy students themselves reported in interview that making the animations was helpful to their understanding. The process forced them to consider what they knew on the subject, highlighting any gaps and triggering research to address them. Opportunities for consolidating learning were also noted with one student reporting 'it was really useful to cement the knowledge'. Another student noted how making an animation 'forced you to identify how each stage slots together rather than just learning them as separate individual stages'. This was important to other students too who highlighted how it made them think through the embryonic structures that change and grow during development in three dimensions and how they were connected. Both groups of students did mention though that the session had taken over an hour and a half and, whilst they'd enjoyed it, they doubted that all of their peers would be content to give up so much time to a small portion of the curriculum being taught. An unexpected benefit nonetheless was that all the students remarked on how having the course lecturer present for much of the time had enabled them to ask questions triggered by small details in the animations. Questions that they wouldn't necessarily have felt up to troubling him about. Thus the way making models for the animations acted as an external representation of their understanding was important and also, as one student pointed out, 'working with others means that you spot things that you would not necessarily spot yourself'.

GW: I had thought that students would learn embryology more easily from animations, but what I failed to foresee was how much they would learn about it by the process of making animations. This was the most impressive part of the work. I became aware of the value of exploring how students learn as opposed to focusing on what they had learned and what they produced. This was a consequence and outcome of an interdisciplinary approach.

Outcomes of the anatomical knowledge pre- and post-test were less conclusive with only two students scoring more highly on the experimental questions in the post test and then by only one mark each as shown in Table 1.

Table 1 Gains in number of test questions answered correctly and confidence level assigned to their answers in the pre- and post-test for each participant

	EXPERIMENTAL		CONTROL	
	Pre-Post Gain in Test Score	Pre-Post Gain in Confidence	Pre-Post Gain in Test Score	Pre-Post Gain in Confidence
P1	1	10	-1	3
P2	-1	3	-1	2
P3	1	13	-1	3
P4	0	7	0	6
Total	1	33	-3	14
Average	0.25	8.25	-0.75	3.5

JW: I was not surprised by this. I think this table clearly shows the problems with using multiple choice questions to assess learning of complex anatomical processes; they are more effective at testing memory for

terms and led to participants guessing answers as indicated by the high proportion of negative knowledge gains. I was wary of the suggested test of learning and concerned as to how repeating the same task would impact on the participating student experience yet it enabled the desired comparison with a control. I find it problematic that evaluating teaching interventions is so often associated with an expectation of greatly increased learning. Humans are hard wired to learn effectively under all sorts of circumstances so I would not expect any one form of learning where students are attentive and engaged to be significantly more effective than another.

GW: This result does not surprise me either as there is a small number of students and of questions. However, this research study revealed to me that the students learned a great deal more than these results imply as they came up with many questions during the creation of the animations that showed they were thinking about what the embryological processes entailed in detail. Until this attempt to animate the material, they had previously viewed embryology as the learning of a series of separate stages in the development of the embryo which they had to imagine as flowing seamlessly into one another. Whilst I had earlier developed a novel, annotated, step by step picture board of the stages in embryogenesis to support students with this transformative process I suspect that many students did not even go this far, merely attempting to rote-learn the stages for later regurgitation. However, when attempting to animate that seamless transition from stage to stage, they realised that important details were missing. A topic that they previously thought was all known suddenly became one where there were not only gaps in knowledge with no answers available from either lecturer or text books but also gaps that both texts and lecturers had ignored. This was a revelation for the students about text books and their lecturer. Students were suddenly brought to the limit of knowledge in the field. It was as if students had suddenly realised that texts were rather like ancient maps where unknown areas were filled in by unsubstantiated comments such as 'here be monsters'. Students immediately realised that there were significant areas where research would be needed, defining for them the limits of our knowledge and indicating areas to research.

MCQs themselves are limited in their ability to test such complex biological processes. It was very clear that the making of an animation on the embryology was a superior assessment of a student's understanding of the topic as it forced the student to think about the topic and all its parts; requiring skills akin to teaching a topic, or functioning at the peak of Bloom's taxonomy of learning [GW is referring to Bloom's taxonomy of educational objectives (Bloom, 1956)].

Also the way engaging in making animations appeared to be associated with increased student reported confidence in their answers to the experimental questions in comparison to those to the control questions was interesting. The two students who did achieve a (slightly) better mark reported the highest increases in confidence however, seeing as for Participant 2 a small increase in confidence was also associated with poorer scores we should be wary of this finding.

Conclusion

In conclusion, it was found that key embryo developmental processes such as neurulation and gastrulation can be successfully animated by undergraduates using 'claymation' in an hour or so. The participating students were positive about learning in this way and gained increased confidence in their subject knowledge however, felt they may not be a representative group and not all their peers would feel the time well spent. The most apparent learning outcomes were related to the way process of creating an animation forced the students to consider what they knew on the subject being animated, highlighting any gaps in their knowledge and triggering research to address them. The multiple tasks of storyboarding, modelling, image capture, editing and reviewing the completed video was perceived to reinforce this learning.

4. Discussion: Reflections on Engaging with Interdisciplinarity

From the commentary reported above under 'Research Design' it can be seen that initially the approach of the two lecturers was multidisciplinary, juxtaposing two or more different disciplinary perspectives (Repko & Szostak, 2017) without gaining improved understanding of the nature of the problem as a whole (Lyall, Bruce, Tait & Meagher, 2015). This can be seen most clearly in GW's comments about the different nature of qualitative research as used in education '*a complementary but very different discipline to mine*', in his recent reflection on this personal writing up process '*...writing this way is alien! Science writing teaches us to be anonymous, and exclude our opinions. It is a strange experience*' and in the decision to go through one faculty's research ethics review process rather than the other. We were clearly looking at the same study from different perspectives thus reinforcing Boix Mansilla, Miller & Gardner's (2000, p.18) point that disciplines are not just collections of knowledge; rather they are lenses through which we look at the world and interpret it. The key foci for GW and the colleagues from FHRS were very outcome driven, for example, the emphasis on the quality of the product and the need to produce a measurable change. This latter observation supports Szostak's (2004) proposition that a discipline's epistemology or rules about what constitutes evidence is an important defining element alongside more obvious candidates such as the phenomena studied and key vocabulary. Evidence anticipated by JW was more nuanced with her expecting the students to share insights as to their learning during the process of animation creation and in the interviews afterwards.

However, over time, a more integrative approach can be seen to appear, for example, with JW sharing insights as to how to approach capturing data through video, her acceptance of the potential value of including a pre- and post-test assessment of student learning and GW's recognition of the importance of process: "*However, this research study revealed to me that the students learned a great deal more than these results imply as they came up with many questions during the creation of the animations that showed they were thinking about what the embryological processes entailed in detail.*" However, this was not the 'conscious integration of disciplinary insights' that Repko & Szostak (2017) consider to be characteristic of interdisciplinarity nor were we working at understanding our own disciplinary culture, seen as essential by Reich & Reich (2006). Rather it was more of an unconscious merging over time triggered by both the need to address the problem at hand and the need to liaise between stakeholders who included the students as well as the FHRS host department academics and support staff. This need to liaise also highlights the importance of addressing how collaborative working and thought were enacted during the project for, as Bevins and Price (2014) showed, actively collaborating is demanding. Both team and task support for the collaboration must be good. Bevins and Price (2014) define team support as the team's combined skill set, mutuality in the relationships between members and cohesion, the value the members give to the team experience whereas task support is the time and space in the workload to engage and collaborate. In our case, our joint interest in animation added cohesion and led us to carve out time and space in our workloads to explore using it for teaching however; it was only when key stakeholders from the teaching team in FHRS became engaged with the pilot that it really took off.

Such an approach, interactive and involving all possible stakeholders, is more typical of transdisciplinary initiatives, those that use collaboration across disciplines and sectors to address complex problems (Krasny, Oshry and Ferguson, 2016). Whilst more commonly introduced in the role of major societal challenges, the concept of transdisciplinarity resonates helpfully here with the complex problem under study being whether it was possible

to identify whether a creative arts based approach (animation) could be used successfully in medical science teaching. For Lattuca (2001) though transdisciplinarity results in individual disciplines being subordinate to a larger framework. Theories, concepts, or methods are not borrowed from one discipline but are applied across disciplines with the intent of developing an overarching synthesis. This focus on application and synthesis, also present in the early definitions of transdisciplinarity (e.g. Gibbons et al., 1994), appears in the above research project when GW refers to the students functioning at the highest levels of Bloom’s taxonomy of educational objectives (Bloom, 1956) in his comment “...it forced the student to think about the topic and all its parts; requiring skills akin to teaching a topic, or functioning at the peak of Bloom’s taxonomy of learning”.

However, such a focus on application leads to questions about the possible status of education itself as a discipline within such transdisciplinary projects for applied research like this tends not to be seen as having as high a status as pure research (Becher, 1994). Indeed, the original concern of a FHRS colleague, that their students would not gain and even might possibly lose out by spending time on the exploratory research project described above, is characteristic of this view. It also supports Zierhofer & Burger’s (2007) concept of separate social knowledge integration being particularly challenging to transdisciplinarity because of different perspectives of ‘qualities of validity’. Yet GW’s conclusions below emphasise the value of colleagues from different disciplines working together to learn from one another:

GW: The research was primarily one in educational method and would not have been possible unless the scientist was prepared to accept the advice and leadership provided by someone experienced in the educational field.

He now even questions the value of the pre- and post-test based on multiple-choice questions typically used in anatomy assessment of student learning. For example, “this research study revealed to me that the students learned a great deal more than these results imply” thus fulfilling Reich & Reich’s (2006) expectation that participants in interdisciplinary research learn about both their own and each other’s disciplinary cultures.

It seems therefore that different disciplinary conceptualisations with their associated foci and emphases appear at different stages throughout an interdisciplinary initiative. Here we started with a multidisciplinary approach and ended with a transdisciplinary one, verging into interdisciplinarity (as defined by Repko & Szostak (2017) with the emphasis on true integration of the disciplines) only every now and then. A more effective way of conceptualising this interdisciplinary-multidisciplinary reverberation is to consider the notion of bricolage. Bricolage itself, referring to a construction made of whatever materials are at hand, was introduced to social science by Lévi-Strauss (1966) in his explanation of how societies create novel solutions by using resources that already exist in the collective social consciousness. For Kincheloe (2001) though, bricolage in qualitative research is concerned, not only with divergent methods of inquiry, but also with diverse theoretical and philosophical understandings of the various elements encountered in the act of research. Elements of interdisciplinary research seen in the above annotated reflections can be conceptualised as aspects of integrative knowledge (Zierhofer & Burger, 2007) that include social knowledge such as values and power relationships as well as more general thematic knowledge (of embryology, of modelling, of how students learn) and more specific problem-oriented knowledge (creating the animation). Also Kincheloe (2001) notes that taking bricolage as an interdisciplinary approach avoids both the superficiality of methodological breadth and the parochialism of single disciplinary approaches. Therefore, as we best

understand it, both lecturers created and carried out the interdisciplinary research initiative on teaching and learning in anatomy reported here, working as bricoleurs i.e. selecting and repurposing aspects of their different disciplinary experiences according to the need of the moment.

JW: Meetings with key personnel were then arranged [...] The proposal itself was rewritten [...] including an explanation of thematic analysis

This selecting and repurposing went beyond Lyall et al.'s (2015) descriptions of interdisciplinary researchers as intellectual butterflies as it was clear that, through conducting the re-designed pilot, our worldviews of teaching and research respectively had changed.

GW: I became aware of the value of exploring how students learn as opposed to focusing on what they had learned and what they produced. This was a consequence and outcome of an interdisciplinary approach.

JW: The proposal itself was rewritten [...] adding a pre- and post- test to assess student learning.

Yet this notion of bricolage is still by and large problem focused and thus represents only the instrumental form of interdisciplinarity. Repko & Szostak's (2017) complementary second form, critical interdisciplinarity, which aspires to epistemological transformation through interdisciplinary research has only been glimpsed here. According to Lattuca (2001) this transformation requires a different way of thinking about intellectual problems and a different way of asking questions. Where a different way of thinking did indeed begin to be seen was in the recognition by the anatomy lecturer that observing this process of students creating animations was more revealing of students' knowledge and understanding than assessing the quality of the products (the animations themselves or the students' test performance).

It was also noticeable that different ways of thinking were exhibited by the students involved. They had little problem adjusting to and acquiring the techniques of animation and what they really gained was a practical understanding of the topic. The requirement to animate rather than memorise stages in a process of embryological development led to them asking searching questions about the intermediate stages needed, many of which there were no answers readily available for. This brought them very quickly to an appreciation of the limitations of existing knowledge and the awareness that their own predictions of what happened next was just as likely to be as valid as any other.

Lastly, as a minor point but one that we hope will be useful for others, we note the unexpected amount of time taken to complete what had been visualised as a small, pilot project centred on an afternoon's teaching. The discussions stemming from the original lack of shared understandings took over two semesters to complete (given colleagues' other commitments). The study itself was carried out relatively quickly with all aspects under the control of the investigators.

5. Conclusions

The issues described in the previous section demonstrate that the integrative research process, long believed to be so central to interdisciplinary research (Hattery, 1986; Qin, Lancaster and Allen, 1997; Repko & Szostak, 2017), needs to be planned for and worked at if a research

team is to make a successful transition from multidisciplinary to interdisciplinary research (Lawson, 2013). Whilst both lecturers clearly learned from each other and moved on from their original disciplinary stance, it is questionable as to whether true integration was achieved. Where integration did occur it was in reaction to the problem at hand emphasising an instrumental underpinning to our interdisciplinary initiative. This then led us to conclude that a more helpful approach to the study of interdisciplinarity, one that would support further pedagogical research in science disciplines in particular, is to focus on the notion of ‘researcher as bricoleur’. A bricoleur selects and repurposes relevant knowledge and experience as needed. Through thinking as bricoleurs we can understand interdisciplinarity better as a process that is achieved over time triggered by the evolving problem(s) at hand rather than a conscious, possibly forced, effort.

Moreover, as Repko & Szostak (2017, p.10) point out that their “distinctions between instrumental and critical interdisciplinarity are not absolute or unbridgeable”, we recommend that next step for education researchers interested in interdisciplinarity is to investigate ways to repurpose our pedagogical knowledge to build the necessary bridges and collaborative strategies amongst research teams. Indeed Chettiparamb (2007) has already made a start linking pedagogical strategies such as active learning with interdisciplinary education.

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