



RESEARCH NOTE

Ask a clearer question, get a better answer. [version 1; referees: 1 approved, 1 approved with reservations]

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Abstract

Many undergraduate students struggle to engage with higher order skills such as evaluation and synthesis in written assignments, either because they do not understand that these are the aim of written assessment or because these critical thinking skills require more effort than writing a descriptive essay. Here, we report that students who attended a freely available workshop, in which they were coached to pose a question in the title of their assignment and then use their essay to answer that question, obtained higher marks for their essay than those who did not attend. We demonstrate that this is not a result of latent academic ability amongst students who chose to attend our workshops and suggest this increase in marks was a result of greater engagement with 'critical thinking' skills, which are essential for upper 2:1 and 1st class grades. The tutoring method we used holds two particular advantages: First, we allow students to pick their own topics of interest, which increases ownership of learning, which is associated with motivation and engagement in 'difficult' tasks. Second, this method integrates the development of 'inquisitiveness' and critical thinking into subject specific learning, which is thought to be more productive than trying to develop these skills in isolation.

Open Peer Review

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Introduction

Supporting the development of critical thinking skills in students can be considered to be one of the key goals of most higher education institutions (ten Dam & Volman, 2004). Critical thinking skills such as analysis, evaluation and synthesis represent the highest levels of learning and literacy capabilities, and are highly sought after by employers (CBI, 2009; Krathwohl, 2002; Miller & Tanner, 2015). Despite the focus on teaching critical thinking skills at university, only ~2/3 of UK graduates (lower than the global average) were capable of exhibiting them during a recent literacy skills survey, which is disappointing given the strong correlation between high level skills and employment among graduates (OECD, 2013; OECD, 2015). This paper evaluates a simple method of encouraging students to engage with these higher level skills in their written assessments.

Chanock (2010) outlines five goals that an essay should fulfil. The first is “presenting a question/problem to the reader” and forms the focus of this study. In our experience, students who fail to achieve high grades on written assignments do so because they write descriptive essays lacking a question or problem to solve; i.e they do not understand goal one (Cottrell, 2011). By defending a position or hypothesis using understanding drawn from wider literature, students can provide evidence of high-level literacy and critical thinking (Kellogg & Raulerson, 2007; Miller & Tanner, 2015). Previous studies support the idea that encouraging questioning behaviour promotes the exhibition of critical thinking by students at a range of levels (Commeyras & Summer, 1998; Keeley *et al.*, 1998; Tsui, 2002). In fact, lack of practice performing critical thinking is thought to be a particularly important barrier to the development of higher-level literacy skills (Cottrell, 2011; Kellogg & Raulerson, 2007). We hypothesise that by making the first objective of an essay more obvious to students, and by encouraging them to approach written assignments as questions that need to be answered, students are more likely engage with higher level learning outcomes (Krathwohl, 2002).

A second cited barrier to the development of higher-level literacy skills is reticence on the part of the student, as essays containing evaluation and synthesis are more difficult to write than descriptive essays (Cottrell, 2011; Keeley *et al.*, 1995). An important aspect of our method involves allowing the students to choose what question they are most interested in within the defined subject area. In this study each student was asked to explore a broader concept associated with a specific animal behaviour they chose to study earlier in the year (for details see Methods section). We believe that the sense of ownership of the task could help to improve engagement with ‘difficult’, higher-learning outcomes, as motivation to engage with studying is thought to be positively associated with personal interest in the topic (Pintrich, 2003).

We propose that coaching students to pose a question in their essay title can integrate ‘inquisitiveness’ development into written assessments. Integration of the development of these skills into the context of the course has been argued as being more effective than trying to teach these skills in a separate course (ten Dam & Volman, 2004; Wingate, 2006). We suggest that students who start by posing a question in the title are more likely to understand the first of

Chanock’s (2010) aims of an essay as well as being more likely to exhibit higher-level literacy skills throughout their writing. Thus, we hypothesise that students who pose a question in their title will obtain higher assessment scores than those who do not, as evidence of higher-level skills are essential in obtaining higher marks.

Methods

Participants

Project participants were students enrolled on a second year undergraduate module *Behavioural Ecology* (UK level 5, 20 credits). We believe this group of 55 individuals to be typical of the wider population of UK undergraduate students enrolled on Honours Degree Programs in the Biological Sciences. 23 of the students were male and 32 were female.

Assessment of the module was by an end of module written examination (50%) and summative coursework (50%). This coursework comprised three tasks (A, B and C) worth 10%, 10% and 30% respectively. Task A required pairs of students to work together to find a short (3 minute) video clip of animals performing a behaviour that interested them and to complete a written assessment in the form of briefing notes for a film crew interested in recreating the video as part of a wildlife documentary. This task encourages observation and description. Task B required individual students to self-assess task A and reflect (in writing) upon their use of the assessment criteria in doing so. This task encourages students to think about the assessment criteria and the way in which they are applied. Task C required students to write a detailed essay exploring the underlying principles and wider context of the behaviour chosen for assessment A. The notes provided to students to explain these tasks are available as [supplementary material \(Appendix 1\)](#).

This project investigates the impact of an optional workshop-based intervention that took place after the students had received grades and feedback on assessments A & B and before they completed assessment C. All students were invited to attend a workshop led by DH and LM as preparation for assessment C with a focus on improving essay writing skills. All students were provided equal opportunity to attend; multiple timeslots were available for students with other commitments. At the workshop, DH & LM explained the function of a good essay in that it should outline a problem that needs to be solved, then present and evaluate the various solutions using wider literature. We suggested that in order to help the students do this they should present a question that needs answering as the essay title, and then use the essay to answer that question with reference to the broader literature (see [Appendix 2](#) for essay titles). We then helped students create a relevant question to ask, suggesting they avoid descriptive ‘how’ questions, and focused on evaluative ‘why’ or ‘to what degree’ type questions.

This activity was not conceived as a research project and because attendance at the workshop was optional student attendance was not monitored. For the purpose of this study we assumed that students who posed a question in the title of their essay had attended the workshop and understood the underlying concepts of the workshop, and this has been used as the independent factor in our analysis. We acknowledge that this lack of certainty in the allocation of students to the did/did not attend category does need to be borne in mind

when interpreting our results. Another possible confounding factor is that voluntary workshop attendance may be skewed towards individuals who are more engaged or motivated with the module; and these individuals are more likely to obtain higher grades because of this higher engagement with the module content (Pintrich, 2003). We have controlled for inherent capability or engagement of the student in this study by including the previous mark on Assessment A of the student as an independent factor in our statistical analyses (see Statistics). Students' essays were marked by an assessor who was not involved in the delivery of the module or aware of the purpose of the workshops but who does have the relevant disciplinary expertise (GS), so as to not influence student grades.

Ethics

Ethical approval for publication of our study was obtained from the University of Hull, SoBBEs ethics board (Code H038). As the significance of the results presented here was only noted after marking had taken place, it was not possible to obtain student approval. However, students cannot be identified individually from the study results or data set, which was deemed sufficient by the ethics board.

Statistics

A generalised linear mixed effect model (GLMM) was used to test for an effect of posing a question as the essay title on the percentage mark awarded to the essay. The student's mark on assignment A was included as a second independent variable to control for the effect of inherent capability. As assignment A was written in pairs, the pair groups were included as a random factor (random intercepts) to control for non-independence of the marks. An observation level, random factor was included to account for overdispersion (Harrison, 2014). As the dependent factor was a percentage, the GLMM was run with a Binomial error structure. All statistics were performed in R using the glmer function in the lme4 package (Bates, 2010) of R v3.1 (R Development Core Team, 2014). The Minimum Adequate Model was established via log-likelihood ratio comparisons using Maximum Likelihood approximation, for which X^2 results indicating significance are reported (Bates, 2010).

Results

Essays with a question in the title scored significantly higher than those without ($X^2_1 = 4.62$, $P = 0.03$; Figure 1 & Table 1). There was no significant effect of score of previous assignment ($X^2_1 = 3.02$, $P = 0.10$), or interaction between the two independent variables (question in title:previous score, $X^2_1 = 0.81$, $P = 0.36$).

Discussion & Conclusion

Our results support our original hypothesis that students who posed a question in the title of their essay would obtain higher grades than those who did not. We suggest that this is because the process of coaching students to use questions to think 'inquisitively' improves the likelihood they will engage with critical thinking skills, such as analysis, evaluation and synthesis. Our results support this because evidence of these skills is necessary for work to be awarded 1st class grades (70% or higher), and we note the

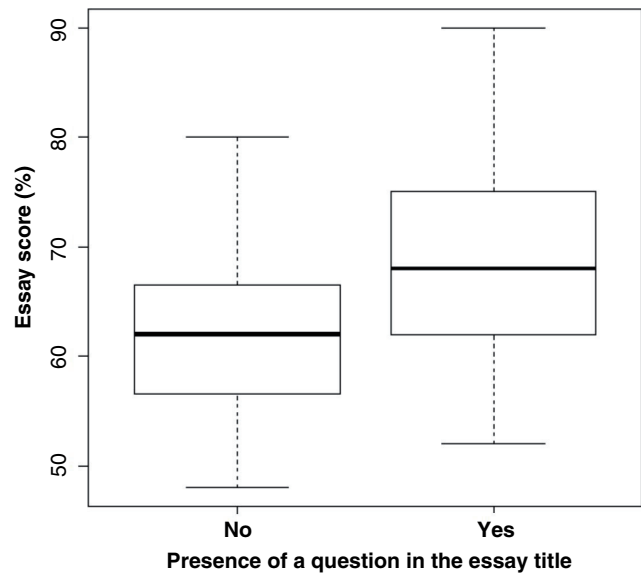


Figure 1. Box plots comparing % scores across essays that included a question in the title and those that did not.

Table 1. Mean percentage scores and standard deviations of students who did and did not pose a question in their essay title.

Did the student ask a question in the title?	Mean score (%)	Standard deviation (+/-%)
Titles with a question	70	10
Titles without a question	63	10

much higher proportion of students posing a question who obtained a 1st class grade (44% [asked a question] vs. 22% [did not ask a question]). Given the importance of critical thinking skills for obtaining higher degree classifications, better literacy scores and gaining employment following graduation, we suggest this outlook may be added to the methods of developing student essay skills (CBI, 2009; OECD, 2013; OECD, 2015). Our method is particularly advantageous because it can be easily integrated into the curricula; as opposed to needing to be taught separately (ten Dam & Volman, 2004; Wingate, 2006). Furthermore, the workshop method in our study focused on helping students develop their own questions to answer, encouraging student ownership and motivation in order to overcome any reticence to engage in 'difficult' higher-level literacy skills (Cottrell, 2011; Keeley *et al.*, 1995).

It is important to state that we believe the whole process of teaching students to think in terms of questions/problems and how to answer them is important; as opposed to merely the act of placing a question in the title. We also do not suggest that this is a

blanket method of encouraging students to develop high-level literacy/critical thinking skills; evidently, some of our students who attended the workshop and used the method did poorly (hence did not grasp the underlying concept) and other students did well despite not using the method detailed herein (Figure 1). This is to be expected where students construct their knowledge base and its application individually and thus respond differently to instruction based on their prior experiences and learning preferences, and does not undermine its validity as a potential tool for broader teaching strategies (ten Dam & Volman, 2004). We concede that a more extensive study, including more students across multiple assessments, is required to resolutely confirm the trends found herein. Further work should focus on helping students to distinguish between descriptive ‘how’ questions and evaluative ‘why’ questions to see if this further improve the efficacy of the method.

Author contributions

DH & LM taught the workshops and performed the statistical analysis. GS performed the marking. All authors equally shared the conceptualisation and development of the project. DH wrote the manuscript with significant input from LM & GS.

Competing interests

No competing interests were disclosed.

Grant information

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Supplementary material

Appendix 1. Assessment notes provided to students.

Assessment title: Assessment A: Documentary Briefing Notes

Weighting: 10%

Submission: electronic submission only

Word count (or equivalent): 1000

Assessment overview:

Your task is to **work in pairs** to produce a briefing paper for a wildlife documentary maker who is making a film about behavioural ecology. You should think of your work as satisfying two needs; it should provide all of the information needed by the film maker; and, it should enable another film crew to replicate the filming should they need to at a future time.

1. Locate a short piece of video footage (<3 min) that clearly shows wild animals carrying out **a particular behaviour**. Your video clip should show a single behaviour, not a series of different behaviours performed by the same animal. In choosing your clip, you should think particularly how you would develop your work on the topic for Assessment C.
 - a. **Background:** Provide a link to the footage (if it is a short section of a longer piece remember to explain where the section of interest starts/stops). Write a brief description of the species involved, geographical location and the best time/location to film the behaviour in question
 - b. **Description:** Write a description of the footage - what does the viewer see? This section should describe what is going on (“the squirrel is burying nuts under dry leaves”), *not* explain what is happening.
 - c. **Explanation:** Here, you should explain what the behaviour is and why the animal is carrying it out (“the squirrel is caching nuts ready for the winter”, and then explain why the squirrel does this)
 - d. **Wider concepts:** Summarise the wider scientific principles underlying the behaviour that you will write about in Assessment C. Think about the general area in which the behaviour lies, that could form the focus of Assessment C. Examples might include optimal foraging, or intersexual selection, or animal migration. This section is not about identifying as many concepts as you can, but about highlighting the topic that you will develop further in Assessment C.

Remember to carefully read the assessment criteria for the task – they provide you with a lot of potentially useful guidance.

Assessment A marking criteria

95	Upper 1st	As for 85, with impeccable descriptions, written clearly and concisely showing very strong evidence of ability to sort and order information into a logical and coherent way. Summary of wider scientific principle shows overwhelming evidence of understanding of concepts at the forefront of the discipline.
90		As for 85, but summary of wider scientific principles may fall very slightly short of excellence.
85	1st	Highly suitable choice of video clip, which displays wild animals carrying out a particular behaviour. Accurate and clear summary of the species, insightful identification of the behaviour, and clear description of it such that film crew can identify behaviour for further filming. Video chosen also allows exploration of clearly identified wider scientific principles. Summary of wider scientific principles display excellent knowledge and understanding. Information is drawn from a wide range of primary sources, clearly and accurately referenced. Language is highly scientific and concise and presentation is excellent.
80		As for 85, but may not be as accurate in behaviour description or identification.
75		As for 80, but may be less well presented, or choice of video may be less suitable.
68	2.1	Suitable choice of video clip, which displays wild animals carrying out a particular behaviour. Clear summary of the species, sound identification of the behaviour, and clear description of it such that a film crew can identify behaviour for further filming. Video chosen also allows exploration of clearly identified wider scientific principles, summarised clearly. Information is drawn from a range of primary and secondary sources.
65		As for 68 but behavioural description may contain some inaccuracies, or wider scientific principles are not summarised clearly.
62		As for 65 but video clip may not be ideal, or some species details may be missing.
58	2.2	Mostly suitable choice of video clip, which displays wild animals carrying out a particular behaviour. Mostly sound description of the species and identification of the behaviour, and clear description of it such that a film crew can identify behaviour for further filming. Video chosen may be less suitable for exploration of clearly identified wider scientific principles, such principles are slightly unclear in explanation. Information is drawn from a range of primary and secondary sources
55		As for 58 but maybe a few inaccuracies in behavioural description, or species details, or referencing may be less sound.
52		As for 55 but some less important elements may be missing.
48	3rd	Video clip chosen, but maybe unsuitable because it is not of an animal in the wild, or cannot be used to illustrate a wider scientific principle, or contains a range of different behaviours. Identification of the species and behaviour is mostly sound, but work may lack a clear description of it such that film crew can identify behaviour for further filming. Wider scientific principles are not clearly explained, or may not be relevant. References drawn from a limited range of sources.
45		As for 48, but some elements may demonstrate misunderstandings.
42		As for 45 but some elements may be missing or demonstrate misunderstandings.
38	Just fail	Fails to identify behaviour in a largely unsuitable video. Makes some attempts at most parts of the task, but some evidence of misunderstandings.
35	fail	Fails to identify behaviour in a largely unsuitable video. Makes some attempts at some parts of the task, but evidence of many misunderstandings.
25		Contains important misunderstandings and inaccuracies that mean that the most important concepts surrounding the task have not been understood.
15		Little evidence of engagement with the task, and contains many misunderstandings and inaccuracies.
5		Negligible evidence of engagement with the task.
0		No relevant material.

Assessment title: Assessment B-self assessment of the briefing notes**Weighting: 10%****Submission: electronic submission only****Word count (or equivalent): 500**

Assessment overview: You should write a short **individual** reflection that explains to the assessor what mark you think your briefing notes (assessment a) will be awarded:

1. State what grade (% mark) you think the work is worth (refer to the assessment criteria for this task).
2. Write a short justification of that mark. In doing so it is important that you refer to the assessment criteria for assessment A and that you provide evidence to support your claim, (you might for example include extracts from the submitted piece as evidence, but pasting in large chunks of your assignment A is a waste of words). In particular, you should focus on the differences between the classification boundaries and explain why your assignment falls into a particular category. Use the assessment criteria for assessment B to guide you in the types of areas you should include in your self-assessment.

Assessment B marking criteria

95	Upper 1st	Excellently written, highly reflective and accurate justification and assessment of the quality of the submitted work demonstrating a clear appreciation of the strengths/weaknesses of the report
90		As for 95, but clarity of expression may fall slightly short of excellence
85	1st	Very well written reflection providing an accurate justification and assessment of the quality of the submitted work. The main strengths/weaknesses of the work are identified, some (few) omitted
80		As for 85 but perhaps a greater number of the strengths/weaknesses of the work are omitted or the justification is less strong
75		As for 80 but the clarity of the justification may be presented less well
68	2.1	Well written reflection providing an accurate assessment of the quality of the work, good attempt to justify the grade awarded. Many of the strengths/weaknesses of the report identified but the assessment of their relative importance in terms of grade awarded may be inaccurate
65		As for 68 but perhaps too few of the strengths/weaknesses are identified
62		As for 65 but perhaps the attempt to justify the mark might be less strong
58	2.2	Mostly well written, reasonable assessment of the quality of the work (e.g. ± 1 band) Largely descriptive with some attempt to justify the award and some awareness of the main strengths/weaknesses of the report
55		As for 58 but being more descriptive and less evaluative
52		As for 55 but demonstrating a more limited appreciation of the key strengths and weaknesses of the work.
48	3rd	Poorly written, poor assessment of quality of work (e.g. ± 2 bands). Largely descriptive work with a very limited attempt to justify the mark awarded
45		Little awareness of even the main strengths/weaknesses of the report
42		As for 48 but entirely descriptive
38	Just fail	As for 42 but demonstrating an almost complete lack of awareness of the strengths/weaknesses of the work
35	fail	Of insufficient quality to be worthy of a pass but demonstrates sufficient relevant content to avoid an outright fail.
25		Poorly written, very little relevant material with major omissions and inaccuracies
15		Contains important misunderstandings and inaccuracies which mean that the most important concepts surrounding the task have not been understood.
5		Little evidence of engagement with the task, and contains many misunderstandings and inaccuracies.
0		Negligible evidence of engagement with the task.
0		No relevant material

Assessment title: Assessment C**Weighting: 30%****Submission: electronic submission only****Word count (or equivalent): 2000**

Assessment overview: Individually write a detailed essay on the scientific principles underlying the behaviour you chose to write about in assessments A and B. You should not simply expand the work you have already done, but focus on explaining the wider scientific concept underlying the behaviour you chose. While your essay should not focus on the particular species in your video clip, you may of course use it as an example within the essay.

We expect you to make extensive use of the published literature (preferably articles from peer reviewed journals) in writing this essay.

Assessment C marking criteria

95	Upper 1st	As for 90, but excellent and comprehensive coverage of the subject, showing deep understanding and including good evidence of critical analysis.
90		Covers all the aspects of the subject thoroughly, showing overwhelming evidence of understanding. Uses and collates information from a wide number of appropriate sources. Impeccable use of English, extremely well presented and structured using appropriate academic conventions. Written clearly and concisely showing very strong evidence of ability to sort and order information into a logical and coherent way.
85	1st	As for 80, but covers nearly all of the topics in the subject.
80		Uses and collates information from a good variety of prescribed and appropriate non-prescribed sources, covers the most important aspects of the subject accurately and without omissions. Shows strong and convincing evidence of understanding of fundamental concepts and some evidence of critical analysis. Well presented using appropriate academic conventions. Written clearly and concisely, showing strong evidence of ability to sort and order information into a logical line of argument.
75		As for 80 but may use fewer appropriate sources, contain a small number of omissions, or lack excellence in presentation/referencing.
68	2.1	As for 65, but shows one or more of: analysis, wider breadth and depth of subject coverage, or better evidence of ability to sort and order information into a logical line of argument.
65		Uses and collates information from a sufficient variety of prescribed sources, covers the majority of the most important aspects of the subject well, shows evidence of understanding and some critical analysis. Mostly well presented using appropriate academic conventions and written clearly and concisely.
62		As for 65, but shows less breadth and depth of subject coverage, or less understanding, or is less well presented.
58	2.2	As for 55, but may include more sources, more clarity, or fewer omissions.
55		Uses and collates information from a small number of appropriate sources. Covers the most important aspects of the subject and shows understanding of the fundamental concepts, but with omissions. Writing mostly clear, presentation shows some effort.
52		As for 55 but may not be as well presented, clearly written, or may contain more omissions.
48	3rd	As for 45, but may include more sources, more clarity, or fewer omissions.
45		Contains some evidence of understanding of a few of the fundamental concepts surrounding the subject, but with many omissions. Draws information from a very small number of mostly appropriate prescribed sources. Limited evidence of ability to sort and order information into a logical line of argument. Writing reasonably clear, presentation shows minimum of effort.
42		As for 45 but may not be as well presented, clearly written, or may contain more omissions.
38	Just fail	Fails to show evidence of understanding of the most important concepts surrounding the subject, although may include descriptions of other aspects of the subject.
35	fail	Fails to show evidence of understanding of the most important concepts surrounding the subject, although may include descriptions of other aspects of the subject and contains some misunderstandings and inaccuracies.
25		Contains important misunderstandings and inaccuracies which mean that the most important concepts surrounding the subject have not been understood.
15		Little evidence of coverage of any topics surrounding the subject, perhaps one or two points which are relevant, little evidence that the most important concepts have been understood, and contains many misunderstandings and inaccuracies.
5		Negligible evidence of coverage of topics surrounding the subject, with omissions in knowledge and understanding.
0		No relevant material.

Appendix 2. Data table used to explore the primary hypothesis.

Gender	Student No	Part A	Part C	Question	Pair	Title
f	1	55	68	Y	m	How Advantageous Is It to Be the Allo-parent?
f	2	75	75	Y	ac	What are the methods used to locate caches created by scatter-hoarding birds and rodents?
f	3	62	62	Y	d	Is co-operative hunting mutually advantageous?
f	4	58	52	N	a	Assessment C
f	5	58	58	N	x	Novel Anti-Predator Behaviour
m	6	62	85	Y	f	Egg discrimination in response to brood parasitism: How do host species recognise parasitic eggs?
f	7	48	48	N	o	Assessment C: Essay
f	8	62	52	N	c	Assessment C- Cooperative Hunting
f	9	65	65	Y	n	What are the different ways in which animals use tools and why?
f	10	68	75	Y	t	How does the function of duet vary across different taxa?
f	11	52	58	Y	ab	How effective is the Method of Bioluminescence when used as a Mechanism for and Against Predation?
f	12	68	80	N	l	Cooperative hunting and its underlying scientific principles
f	13	62	68	Y	b	Critically discuss the mechanisms through which female choice arises. How do these mechanisms apply to colour preference and what is its importance?
m	14	62	80	N	c	Assessment C
f	15	62	65	N	d	Animal Behaviour: Cooperative hunting in groups of animals.
m	16	48	80	N	g	Intraspecific Fighting Behaviour in Animals
m	17	55	68	Y	m	What are origins of cooperative breeding?
m	18	75	62	N	q	Scientific principle and concept of the defensive behaviour
m	19	55	65	N	s	A Brief Overview Of Social Foraging Behaviours
f	20	65	75	Y	v	In the absence of direct benefits; comparing the indirect benefit models: Fisherian and Good genes. Which of those two theories of intersexual selection best explains the reasoning behind female choice?
f	21	55	75	Y	u	Does group size affect an individual's vigilance regarding predation risk?
m	22	62	80	N	w	Methods and Processes Underlying Sexual Selection in Animals
m	23	55	62	N	s	Behavioural Ecology: Assessment C
m	24	55	58	N	aa	The Concepts of Optimal Foraging
f	25	52	55	N	ab	Assessment C – Bioluminescence and the Wider Concept
m	26	65	75	Y	v	Good genes vs. Sexy sons
f	27	65	65	Y	y	Do females benefit from classical lekking?
f	28	62	68	N	z	The effect of social behaviours on tool use
m	29	68	75	N	ad	Wider concepts: the vocal learning and ultimate causation of bird song
f	30	58	48	N	x	Defence Mechanisms of Lizards
f	31	62	85	Y	f	What are the origins of brood parasitism in Birds?

Gender	Student No	Part A	Part C	Question	Pair	Title
f	32	65	85	Y	y	If subordinate males seem to gain no immediate benefit, why do they take part in cooperative lek mating behaviour?
m	33	62	65	N	w	Assessment C
m	34	75	62	Y	q	What are the most effective defensive behaviours?
m	35	52	55	Y	p	What is the importance of Dominance in a hierarchy and the benefits of being dominant?
f	36	68	85	Y	t	Can vocal duetting be used to accurately determine the strength of a pair bond in a mated species pair
f	37	52	58	N	e	Wider concept of marine bioluminescence functions
f	38	55	75	Y	r	Is female sexual selection important prior to reproduction?
f	39	52	75	Y	p	Is it Ultimately Beneficial to Seek a Dominant Rank within a Dominance Hierarchy?
m	40	38	62	Y	h	Why is Cooperative Breeding Selected for in some Social Organisms Despite it's Apparent Negative Effect on the Individual's Fitness?
f	41	65	62	Y	n	To what extent is tool use by animals predominantly for the purpose optimal foraging?
m	42	38	68	Y	h	To what extent is Kin Selection theory the primary evolutionary driving force responsible for the presence of altruism in nature?
m	43	55	55	Y	aa	Is the utilisation of the Earth's geomagnetic field an operational method of hunting or foraging?
m	44	48	55	N	g	Intrasexual competition
f	45	68	75	Y	l	What are the Benefits of Cooperative Hunting and does it Influence the Grouping Behaviour of Animals?
f	46	58	62	Y	j	Does living in a large group make an individual more or less likely to be predated upon?
m	47	58	65	N	j	Assessment C: Group defence
m	48	55	90	Y	r	How has sexual reproduction evolved despite a two-fold cost and how has sexual reproduction coupled with Mate choice led to the production of elaborate signalling displays, the like of which is performed by the Male Peacock Jumping Spider (<i>Maratus volans</i>)?
f	49	62	62	Y	b	Do the costs of intersexual selection outweigh the benefits?
m	50	68	52	Y	k	What is the Function of Aggressive Mimicry?
m	51	48	62	N	i	Wider Scientific Concepts: The significance of exaggerated features
f	52	62	90	Y	z	and their role in courtship behavior in animals
f	53	55	65	Y	u	How does social learning affect individual's food preferences within socially foraging groups of individuals?
m	54	48	58	N	o	REPRODUCTIVE BEHAVIOUR: INTERSEXUAL SELECTION AND DANCING SPIDERS
f	55	68	65	Y	k	How do Aggressive Mimics use False Signals to their Advantage?

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Bates DM: **lme4: Mixed-effects modeling with R**. Springer. 2010.

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Open Peer Review

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Version 1

Referee Report 13 October 2015

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Kay Yeoman

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Critical thinking is certainly a key skill which we would like our students to develop during their time in Higher Education. The paper points to the OECD studies showing that students tend to lack these critical thinking skills. I think it would also be good to highlight the evidence for this in the education literature.

The paper looks at an intervention through an optional workshop to coach students to think about framing essay titles into questions. The hypothesis being that those who formulate questions achieve a higher mark when compared against those who did not.

In the methods it would be good to clarify if the gender ratio of that particular module is typical of the wider cohort, it is suggested, but not implicitly stated. It would also be good to know if there were any mature students in this cohort (maturity being another confounding factor). The workshop was optional, giving rise to a group without the intervention, and a group with the intervention (control). It would be good to have a table here showing the numbers in each group, and the gender and age split. The authors suggest a confounding factor in that more motivated students (possibly achieving higher grades) were more likely to opt in. It would be interesting to look at gender and maturity as factors as well within the self-selecting group vs control group.

I would like to see more information about the intervention workshop, how was it run? How long was it? Did the workshop only cover the framing of titles as questions, or did it also cover the structured argument required to answer the question? Did students who attend this follow up conversations within the workshop with further questions? If so, how would this have influenced their final grade? Do you have any qualitative data from student feedback to show you what was valued within the workshop? The paper states that the independent assessor who marked the essays was unaware of the study being conducted. Were the essay titles removed prior to marking?

I think it would be good for the discussion to examine the recent rise in the number of A-levels students taking the extended project qualification (approx. 33,000-data can be obtained from the Joint Councils for Qualifications). This dissertation requires students to formulate a research question, and then to investigate and critically analyse sources. This is becoming an increasingly popular and important qualification, and is set to rise with the removal of the AS examination. It would be good for the authors to discuss what future impact this might have on the quality of critical thinking of our students as they enter into higher education.

I think this paper hints at straight forward intervention within the curriculum which could help develop

critical thinking skills, but I think the needs more evidence over at least another cohort of students on the same module before the influence of the workshop can really be shown on student attainment.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Competing Interests: No competing interests were disclosed.

Referee Report 07 October 2015

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This paper considers a workshop conducted to support students preparing a summative written assignment, which had the unplanned benefit of improving critical thinking skills, as evidenced by higher assignment grades. The development of higher-order thinking skills in undergraduate students is of considerable relevance in relation to the employment prospects of the increasingly diverse student body; this study is therefore a useful contribution to the literature. I have some suggestions below, consideration of which may improve the paper.

Hypothesis 1. There is overlap between hypotheses 1 (“...by encouraging [students] to approach written assignments as questions that need to be answered, students are more likely to engage with higher level learning outcomes”) and 2 (“...students who pose a question in their title will obtain higher marks, as evidence of higher-level skills”). Hypothesis 1 is not tested by any analyses, and I can’t think of an appropriate approach to do. Since demonstrating higher-order learning outcomes and gaining higher marks are so closely related, perhaps no further analysis is warranted and H1 should be lost. If H1 is retained, the analyses and the *Results* will need expansion.

Learning outcomes. Achieving higher-level learning outcomes by demonstrating critical thinking skills is at the heart of this paper. However, whilst the *Assessment C marking criteria* allude to higher-level learning outcomes (e.g. “shows convincing evidence of understanding” compared to “fails to show evidence of understanding”), no specific words (e.g. *evaluate* compared to *describe*) are used. Therefore, evidence that higher learning outcomes have been achieved could be more explicit; perhaps some descriptive text (including essay extracts) could be added to the *Results* to provide qualitative evidence that higher level learning outcomes were met.

Participants. More detail of the cohort characteristics would be useful to justify the “We believe this group” statement, in particular in relation to ethnicity. At my own institution, BME groups are poorly represented on the Ecology pathway of BSc (H) Biological Sciences (who would take a *Behavioural Ecology* module) compared to, for example, those studying Biomedical Sciences. In the context of ‘Narrowing the Gap’ initiatives, the ethnic composition of the cohort could usefully be clarified.

Methods. The Methods are clear and supplementary material is very useful. More detail could be provided on some aspects to meet the journal guideline that the work should be repeatable by others. For example, clarify how the “function of a good essay” was “explained” (could further supplementary material usefully be provided)? The statistical approach used is robust - would a brief description of /

introduction to GLMMs (or perhaps a reference to further information) be useful? Expanding on my 'Participants' comments, consider whether analyses exploring differences between cohort sub-groups (e.g. ethnicity groups) would be useful

Results. A few basics need adding e.g. how many students were in the "with" and "without" groups. Also, as mentioned in the *Learning outcomes* section above, consider adding qualitative evidence that higher level learning outcomes were met. Finally, the information presented in Table 1 is very limited and replicates Figure 1; I suggest Table 1 be lost and the mean / SD included in the text.

Discussion. As well as recommendations for future research, the Discussion could usefully clarify how you might adapt the seminar in future, to maximize benefits and reduce the proportion of students who do "not grasp the underlying concept".

Study limitations. The lack of certainty about which students did / did not attend the workshop is unfortunate, but the limitation is recognised and this limitation does not undermine the usefulness of the study. Similarly, the lack of replication does reduce confidence in the results, but recommendations for a more extensive study are appropriate.

Minor points

- I cannot spot <8 key words, have these been provided?
- "presenting a question/problem to the reader" isn't a direct quote from Chanock, so I'm not sure quote marks are suitable.
- Use the past tense to describe work done: *allowed* in the Abstract; *investigated* in the Methods.
- Information about all methods is under the "Participants" subheading.
- It's odd to specify "examination... summative coursework" – both assessments are summative.
- Avoid undefined abbreviations e.g. "SoBBEs"
- The semi-colon is used incorrectly e.g. "module; and these" "important; as opposed"; the clause after the semi-colon must be capable of standing alone as an independent sentence.
- Ensure phrases are sufficiently specific e.g. "to help the students do this" is a bit vague.
- Look for opportunities to be more concise e.g. remove "in order to" / "it is important to state that".
- The ampersand is informal so should be replaced with *and* (e.g. "DH & LM")

Hyphenate adjectival phrases e.g. *subject-specific*.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Competing Interests: No competing interests were disclosed.

Author Response 12 Oct 2015

Dominic Henri, University of Hull, UK

Thank you very much, some really helpful points here. We will create a full response when we hear back from the third referee.

Competing Interests: No competing interests were disclosed.