The aptness of fit between task design and students' written work: Illustrations of harmony and dissonance in science and history classrooms

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Abstract

Educational practice requires teachers to manage the intellectual space surrounding learning in their classrooms. Prototypically, teachers' decision making involves identifying learning objectives and then organising activities that lead students towards the production of artefacts that demonstrate their understanding of key concepts and information in designated fields of study. However, in practice, there are occasions where teachers' designs and students' output are misaligned and this phenomenon usually has a negative impact on students' levels of achievement. Explaining how and why students' work fails to meet expectations is a sensitive matter that may not be adequately explained by simplistic deficit models concerning the child.

Drawing on data collected as part of CRPP's Digital Curricular Literacies project, this paper reports preliminary relationships between learning task characteristics (outcomes, strategies, scaffolding), teachers' process goals (e.g., remember, understand, evaluate) in lower-secondary science and history classrooms and the quality of students' work. Our subsequent discussion focuses on cases where student underachievement seems to be attributable to imprecision in learning task design and/or inadequate classroom practice. Potential consequences on students' ability to communicate will be highlighted and suggestions made about scaffolding students' learning successfully in the completion of ill-structured learning tasks.

Introduction

The Digital Curricular Literacies (DCL) suite of studies sets out to address three interrelated questions:

1. How do teachers prepare students in science and in history to work on extended learning activities (i.e., built around focused topics and using a range of (re)source materials)?
2. How do students collect and synthesize linguistic and multimodal information as they work on their projects?
3. Can the quality of these projects, the nature of the classroom interaction, and the nature of research activities that students conduct online in the course of working on their projects, be systematically enhanced via targeted interventions focused on:
    - The linguistic structure of the key genres in the discipline area;
    - The aptness of fit and function provided by multimodal information in the materials encountered in conducting a project; and
    - The explicit design of more open-textured tasks across the course of a unit of work?

This paper relates to the analysis of student artefacts collected at different times in various units of school-work observed. It is focused on the relationships between learning task characteristics (outcomes, strategies, scaffolding), teachers' process goals (e.g., remember, understand, evaluate) and the quality of students' work in lower-secondary science and history classrooms. The paper is organized as follows. First, we propose a working definition of learning tasks used for the coding schemes that we have developed to analyze student artefacts. We then present the preliminary results of an analysis of data collected that pays particular attention to possible differences in the quality and quantity of student work produced before and after our intervention programmes. Finally, we conclude with a discussion of the pedagogical implications of our research.

Learning tasks

Learning tasks are the cornerstone of classroom interactions and can be said to give meaning and purpose to the resources and supports used in teaching and learning. To illustrate their centrality in a teacher's work, consider, for instance, Vygotsky's (1978, p. 86) definition of the zone of proximal development as "the distance between the actual developmental level [of a child] as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers". In our view, the function of moving the child from a lower level of development to a higher level across the zone of proximal development is performed by learning tasks. That is, well-constructed learning tasks provide the scaffolds that enable the child to do what he or she cannot do alone. Insofar as the development and application of the DCL coding scheme is concerned, a learning task may be usefully understood as involving students working to complete an activity or sequence of activities that have both desirable and measurable outcomes.

Identifying task design structures

One possibility for describing and classifying learning tasks is by making reference to the nature of the structure and degree of certainty of the subject matter with which they are concerned (Freebody, Hedberg, & Guo, 2003). To show that the *knowledge domain* in which a task is situated influences possible and desirable outcomes, Jonassen (1997; 2000) proposes a continuum of instructional design models that is based on a distinction between well- and ill-structured problem types. At one end of the continuum, well-structured problems typically involve learners in applying a limited number of concepts, rules and principles in a restricted problem situation. Under these circumstances there is usually a correct and predictable answer or solution to be sought through a process that is usually preferred and/or prescribed but importantly, not contextualised. At the other end of the continuum, ill-structured problems are prototypically context-specific, authentic, using real world understandings and seeking solutions (where possible) that are not predictable in advance and the strategies by which they are achieved are based on individual choice and a variety of optional paths. When setting learning tasks, teachers make decisions that serve to *regulate* or *control* the type and amount of work to be done by pupils. For example, the amount of time that is available for the planning and completion of a task may be set in advance; the modes in which meanings are to be represented may be pre-determined and the amount of information to be handled may be limitless or highly-circumscribed.

When analysing students' artefacts, DCL coders were trained to make a judgment call on the type of tasks set by the teachers. Table 1 lists the categories and options available for use in the coding scheme. Table 2, to be read in conjunction with Table 1, shows how the structure of prototypical tasks in history and science shapes the kind of artefact produced by pupils.

Table 1: Categories and options available in the coding of teachers' learning task designs

Category	**Options**
Open-/Closed-textured	The knowledge domain that the task is situated in is: 1. Closed-textured 2. Somewhat closed-textured 3. Somewhat open-textured 4. Open-textured
Multiple Strategies (whether the task allows pupils to achieve task outcomes in more than one way)	1. The task does not allow pupils to utilise multiple strategies to achieve task outcomes 2. The task allows pupils to utilise multiple strategies to a limited extent 3. The task allows pupils to utilise multiple strategies to a moderate extent 4. The task allows pupils to utilise multiple strategies to a large extent
Multiple Outcomes (whether the task allows pupils to provide different correct or acceptable answers)	1. The task does not allow pupils to arrive at multiple outcomes 2. The task allows students to arrive at multiple outcomes to a limited extent 3. The task allows students to arrive at multiple outcomes to a moderate extent 4. The task allows students to arrive at multiple outcomes to a large extent
Scaffolding (whether the task is presented in a highly scaffolded/structured or weakly scaffolded/structured way	1. No scaffold 2. Weak scaffold 3. Moderate scaffold 4. Strong scaffold

Table 2: Prototypical tasks in History and Science showing how task structures shape the kind of artefact produced by pupils

	History	Science
Topic	Early Civilisations	Mass and Density
Time	1 hour	Unspecified
Question	What is civilisation?	What is the volume of a stone?
Procedure	The teacher defines civilisation and then organises an inquiry-based activity that involves pupils in the examination (with guiding questions) of specific secondary sources dedicated to the rise of south east Asian civilisations. At the end of the task, the teacher asks for a summary of the information found.	This is a workbook activity. Pupils are told that a stone is too large to go inside a measuring cylinder. How, then, can the volume of the stone be determined? Some or all of the following apparatus are provided: thread, a stone, tripod, beaker, displacement can and a measuring cylinder (drawings of these items are provided). Next, the pupils must describe their proposed method using words and diagrams (space is provided on the workbook page).
Commentary	In this task, pupils are required to understand and reproduce information in a predetermined fashion. Although it is likely that the teacher has a set of preferred responses in mind, there is likely to be a small amount of freedom in the way the pupils choose and prioritise the information presented. Given the guided inquiry nature of the task, pupils could employ a number of different strategies in completing the task. For example, they could produce a chart, table, drawing, text or combination of these.	This task is framed as a problem-solving activity where pupils must produce an illustrated procedural text. But there is only one answer possible and one strategy or method that can be used to obtain the solution to this well-structured puzzle.
	Ratings	
Open-/Closed-textured	2	1
Strategies	3	1
Outcomes	3	1
Scaffolding	3	4

Data analysis

The research study team collected from each participating teacher ten pieces of pupil work on every classroom visit, where possible. In each case, a request was made for three good pieces, four average ones and three below average exemplars. Where an artefact consisted of different text types, we split the item and created a coding file for each major text type therein. On occasions when an artefact consisted of multiple-choice exercises and/or short answers of no more than two sentences, we did not go any further than noting these phenomena on the opening page of the coding sheet. Once all the artefacts were analysed for the linguistic features of the text type concerned, task design and multimodal features, data from the coding sheets (Microsoft Excel format) were entered into SPSS software for further statistical analysis.

Preliminary findings

The preliminary findings reported in this section relate to pupils' artefacts in history and science classrooms collected at two distinct phases of the research project. The first data collection point (hereafter referred to as DC1) occurred in the early stages of the study and as such constitutes the baseline for subsequent comparisons. The second data collection point (DC3) followed an intervention phase where the collaborating teachers were introduced to new teaching and learning techniques in a series of workshops and follow-up meetings. The purpose of these interactions was to motivate the participants to experiment with divergent thinking and problem-based pedagogies (Anderson & Krathwohl, 2001; Jonassen, 2000).

Tables 3a and 3b show for the subject areas of History and Science respectively, t-test comparisons between DC1 and DC3 in the four variables of task design of interest in the study: degree of openness pertaining in the knowledge domain (texture), multiple strategies, multiple outcomes and scaffolding. The number of artefacts analysed at each data collection point for both disciplines is given under the 'Frequency' heading. The unequal distribution in the number of artefacts considered for both subjects across treatments is due, unfortunately, to the constraints of school timetabling and the availability of classes for observation. Additionally, not all classes observed produced written work.

Table 3a: A comparison of task design variables in History

Subject	Items	DC1		DC3		Significance
		Frequency	Mean (SD)	Frequency	Mean (SD)	
History	Open-/Closed-textured	154	2.02 (0.46)	32	1.25 (0.44)	0.000
	Multiple Strategies	154	2.10 (0.57)	32	2.72 (0.52)	0.000
	Multiple Outcomes	154	2.98 (0.68)	32	2.72 (0.52)	0.042
	Scaffolding	151	0.91 (0.89)	32	0.03 (0.18)	0.000

Table 3b: A comparison of task design variables in Science

Subject	Items	DC1		DC3		Significance
		Frequency	Mean (SD)	Frequency	Mean (SD)	
Science	Open-/Closed-textured	108	1.62 (0.94)	171	2.41 (0.71)	0.000
	Multiple Strategies	108	1.88 (0.71)	171	3.43 (0.53)	0.000
	Multiple Outcomes	108	2.15 (0.96)	171	3.56 (0.53)	0.000
	Scaffolding	108	0.82 (0.85)	171	0.29 (0.47)	0.000

Tables 3a and 3b clearly show movement and difference but space precludes a full-blown analysis of all of the trends. Potentially there are manifold explanations that could be given for the changes that occurred. But given the inherent complexities of classroom interactions, each would need to be unpacked carefully in order for justice to be done to teachers, pupils and schools involved in the study. Therefore, in the remainder of the paper, we limit ourselves to answering two questions that seem to us essential in understanding, in the broadest sense, the research intentions behind the data collected. These are:

1. What profile in relation to students' written work in History and Science teaching and learning can be derived from the baseline?
2. Do the results for DC3 show an improvement in task design practices?

As far as the first of these questions is concerned, let us consider History and Science as separate cases and then identify a major concern arising from this phase concerning the aptness of fit between task design expectations and students' written work.

DC1 History

Referring to Table 3a: with mean scores of 2.02 (s.d. = 0.46) for Open-/Closed-textured, 2.10 (s.d. = 0.57) for Multiple Strategies and 2.98 (s.d. = 0.68) for Multiple Outcomes, there is evidence to show that lower-secondary History students are regularly set tasks where constraints in the knowledge domain are offset to a moderate extent by freedoms to arrive at desired knowledge outcomes in more than one way. This line of argument would be consistent with a view of History learning that gives primacy to the understanding (read memorisation) and reproduction of historical 'facts' but allows students to 'discover' these items from a variety of sources and present them in a variety of formats. That being said, the mean score for Scaffolding of 0.91 (s.d = 0.89) illuminates how students are expected to work in History lessons. This low rating indicates that History teachers seldom provide content or procedural guidance on how to complete the tasks that they set. We return to the potential consequences of this phenomenon in a moment.

DC1 Science

The DC1 Science descriptive statistics from Table 3b provide an interesting discipline-related effect in comparison with History. Notice how the mean scores of 1.62 (s.d. = 0.94) for Open-/Closed-textured, 1.88 (s.d. = 0.71) for Multiple Strategies and 2.15 (s.d. = 0.96) for Multiple Outcomes are lower. These results demonstrate how learning science at this level requires less interpretation and variance in finding and reporting results. For instance, there are (often for safety reasons) established procedures for setting up and using laboratory equipment in the completion of tasks that have known outcomes. Due perhaps to a lack of time or more probably to a lack of necessity, the discussion of results under these circumstances is rare. It is also productive to consider why Scaffolding is weak in lower-secondary Science lessons. One possible explanation is that teachers would, in effect, be giving the answers away if they were to provide guidance in the content and procedures involved in completing well-structured tasks. This is because these kinds of problems do not, by definition, feature Multiple Outcomes or Multiple Strategies (cf., Jonassen, 2000).

DC1 Issues arising

As we analysed students' written work in the baseline dataset (DC1) we asked ourselves: 'How do the students know what to do?' In Science, this question is less contentious as procedures are usually explicit and predictable. Under these circumstances we propose that there is, prototypically, characteristic harmony between what the science teacher requires and what the students provide (but see below). Whether this is a good thing in terms of learning science effectively is a separate issue for the time being.

However, it is not always the case in *History* that designs of tasks, students' responses and teachers' expectations are aligned as the following case from our dataset shows. Figure 1 gives an instance of a class examination question where Multiple Strategies and Multiple Outcomes were possible but were also problematic.

Figure 1: History examination question where multiple strategies and outcomes seem likely

18. The 1819 Treaty was just the first step in legitimizing British claims on Singapore. Discuss. (6 marks).

Our sample of ten artefacts relating to this question shows there were various responses and scores awarded by the teacher as shown in Table 4.

Table 4: Various responses and scores awarded to the same task in a History examination question (as shown in Figure 1)

Serial no.	Text type produced	Score awarded
1	Factorial explanation	1 / 6
2	Exposition	1 / 6
3	Recount	3 / 6
4	Recount	3 / 6
5	Exposition	1 / 6
6	Recount	2 / 6
7	Historical account	3 / 6
8	Recount	3 / 6
9	Historical account	2 / 6
10	Recount	2 / 6

Why should we be concerned about students faring differently in this way? Well, apart from the scores being low across the board, from the marks awarded, we gather that the teacher expected the pupils to produce a Recount or a Historical account and, perhaps, the ideal Discussion. But the phrasing of the task does not do justice to the teacher's intention, at least from the perspective of the pupils' current and potential understanding. Put starkly: the trouble, in our estimation, stems from the ambiguity surrounding the word 'Discuss' which could mean, as outlined by Sinclair (1987, p. 401):

1. You consider it [something] thoroughly, from different points of view, by talking to someone else about it; or
2. You write or talk about it in detail.

If the student happened to interpret 'Discuss' in the first sense, then he or she would be likely to write a Discussion, commenting on various points of view regarding this issue. If, however, the pupil happened to be more familiar with the second sense, then he or she would come up with some other text types in response to the question. What exactly did the teacher expect the students to produce in response to the question set in Figure 1? We cannot tell. Unfortunately neither could the students and this uncertainty could be the product of weak scaffolding in classroom-based activities.

We now consider briefly an instance of misalignment in Science. Whereas in Science the pupil usually knows what to do, as noted above, there are exceptions, where the lack of proper guidance and structure results in pupils' mindless mass lifting of information from an Internet source. We observed that once in a while, the teacher might assign mini-project work. He or she divides the class into several groups and has each group work on one topic. Each group is to present to the class what they have found either in Microsoft PowerPoint format or otherwise submit a project report. The topics are from the lessons the teacher has just taught or is teaching. For example, when covering the unit of classification of animals and plants, the teacher might assign a mini-project asking pupils to look on the Internet for additional information on vertebrates, conifers, fish mammals and so forth. Other than outlining the outcome and expectation, unfortunately, he or she usually gives no guidance to the pupils as to how to be an effective and efficient user of the Internet. As it turns out, the pupil's role is just to search with the Google (for example) search engine, cut and paste, save to his or her diskette, and present to the class and / or hand in a written product. He or she doesn't even have to understand what is put together. We cite two examples of students' work. One is titled (ironically) 'My Report on Enrico [Fermi]' and the other 'Submarines'. Had they been produced by the pupils, they would have counted as clear evidence of meaningful learning taking place, but these two artefacts were directly lifted from Web sources http://nobelprize.org/physics/laureates/1938/fermi-bio.html and http://www.yesmag.bc.ca/how_work/submarine.html respectively. There were no attempts to analyse, contextualize or apply any of the information found. Or rather, the pupils lacked the skills to internalize and process information in order to turn it into meaningful and relevant knowledge that they can access and write about. More than that, the artefacts revealed an inability to question the sources and facts presented on-line critically. This worrying phenomenon must be curbed by the teachers for 'an unquestioning mind is one condemned to "feeding" on ideas and solutions of others. An unquestioning mind may have little defense against the data smog so typical of life in this Information Age' (Jonassen *et al.,* 2003, p. 44).

DC3 History

The results for DC3 History presented in Table 3a portray a very interesting and somewhat complex picture following the intervention phase of the study. Significant movement can be seen in the mean scores relating to knowledge domain, Multiple Strategies and Scaffolding. As far as knowledge is concerned, the mean score of 1.25 (s.d. = 0.44) for the Open-/Closed-textured variable has served to narrow the range of choices available, perhaps so that pupils can learn the academic code of writing History more effectively. The message underlying this trend would seem to be: not everything goes. By contrast, there has been a slight easing in the Multiple Strategies category suggesting that teachers have given pupils more freedom to think on their own. Advocates of a *thinking* approach to learning might be encouraged by this development, especially in light of the dramatic fall in Scaffolding to virtually zero. However, there is also a case to be made that says that the learning of History has become more like DC1 Science where high value is placed on the memorisation and reproduction of authoritative sources of knowledge.

DC3 Science

DC3 Science is now more *open*-textured than History ever was! Taken together with a large increase in the Multiple Strategies variable and a diversification of Outcomes, the messages from science teachers seem to be squarely enterprising: choose more of your own goals and achievement strategies; take risks and worry less about the fear of failing. However, while one might applaud a move away from 'cookbook' science where instructions are followed unthinkingly, optimists should be mindful of the fall in the mean for the Scaffolding variable to just 0.29 (s.d. = 0.47). It is one thing to be cut loose from the chains of a restrictive curriculum and the spoon feeding this fosters but it is quite another to be set to sea in a boat with a life jacket.

Implications

Given the preceding points, we are in two minds as to whether the DC3 data indicate an improvement in teachers' task design practices. In many respects, the results are inconclusive but the potential for change is present and there is a definitely an open, *blue sky* beyond the immediate cloud cover above. Theoretically, our position in the task design intervention was that there were likely to be learning benefits derived from a movement towards more ill-structured problem setting and solving in both History and Science. In this respect, Jean Anyon (1980/2000) offers a typology of North American schooling that is instructive in this context. In the working-class school, the key is to follow instructions (so that when you grow up, you won't do any damage to the machinery in the factory); in the middle-class school, it is to get the correct answer (and a good job when you graduate) and in the executive elite school, work is undertaken in order to seek in-depth understanding, create new knowledge and get people mobilized/organized around a task (for this analysis we are not including

Anyon's affluent professional school). From the comparison of the DC1 and DC 3 dataset, we are probably witnessing a move in teaching toward the middle-class and even the executive elite school work but there is a lot more work that needs to be done.

As far as we are concerned, crucial momentum is lost in History and Science classrooms when students have to second-guess the teacher's intentions. Thus, we believe that an essential component in any teacher professional programme must be the design of learning tasks where the teacher's expectations are made as explicit as possible. What is more, we maintain that in order to ensure a good fit between task design and pupils' output, it is crucial for the teacher to provide appropriate scaffolding in learning tasks in terms of content and procedure so that they are truly provided with meaningful opportunities to not only enter into a zone of proximal development but also to prosper and learn within it.

Closing remarks

Teachers vary considerably in their acceptance of the role and responsibilities as task designers in their classrooms (Towndrow, 2005). What is more, their mastery in using learning task design skills and strategies is open to wide variance depending on knowledge and experience of applying task design principles. The likely outcome arising from these factors is that some learning tasks in History and Science teaching in lower secondary classrooms in Singapore, as reflected in pupils' written work, is better designed than others.

In this paper we have proposed a set of parameters through which to analyse teachers' task designs and hinted that teachers have the potential to transform and improve classroom pedagogic practice in terms of disciplinary writing at the secondary one level in History and Science. At the same time, our analysis of the complex post-intervention data has also cautioned us that for this potential to be realized in effective task design in the classrooms requires careful design, long-term collaboration between researchers and teachers, and the necessary climate for fundamental systemic change.

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