Evaluating Innovative Collaborative Learning Practice: An 'Innovative' Delphi Approach

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Teachers need to know what aspects of any proposed innovative practice are supported by evidence and are likely to be effective. However, when there is insufficient time or money to conduct a detailed trial of each proposed innovation, are there other less resource intensive methods that can be used? Here, we present a study conducted with thirty-six learning sciences experts and practitioners who were asked to judge the potential effectiveness of eighty collaborative learning activities using an adaptive comparative judgment (ACJ) approach. The results of the ACJ process show that the most innovative and effective collaborative learning activities are those that are monitored but not formally assessed. In addition, the use of technology and explicit support of students' social and problem-solving skills are identified as important features of innovative collaborative learning activities that are likely to be effective. The contribution of this paper is twofold. First, it presents features of innovative collaborative learning practice that are considered to be important for effectiveness by experts. Second, it provides an 'innovative' research approach to assess educational practice when teaching is considered as a design science rather than a theoretical science.

Introduction

Collaborative learning is a teaching approach in which small groups of students work actively to achieve their common goals. It provides students with opportunities to augment each other's learning experience through meaningful interactions. The meta-analyses and best evidence syntheses demonstrate that, when implemented appropriately, collaborative learning approaches do produce positive effects on pupil learning, motivation and attitudes. Meta-analyses show that classroom-based studies of collaborative learning consistently show advantages for collaborative group-based learning in classrooms, especially in comparison to 'control' classes where the pupils study the same curriculum topics but under 'traditional, teacher-directed' or individual learning practices (See for instance Johnson & Johnson, 2002; Kyndt et al., 2013). Indeed, the Education Endowment Foundation in the UK equates the impact of collaborative learning approaches on attainment to an additional five months of schooling (EEF, 2017).

In addition to evidence about the positive impact of collaborative learning on achievement and attitude, there is also evidence that collaborative learning approaches lead to higher motivation than other traditional approaches to instruction (Johnson, Johnson, Roseth, & Seob Shin, 2014), and to encourage students to be active participants in their own learning (Webb, Troper, & Fall, 1995). However, although this evidence of effectiveness exists, there appears to be highly variable practice in the nature and quality of the implementation of collaborative learning (Abrami, Poulsen, & Chambers, 2004). Very few teachers have appropriate training to implement collaborative learning activities and most teachers have virtually no time to design effective collaborative learning activities and support the learners as they would like. This was true, even among the trained teachers studied by Antil, Jenkins, Wayne, and Vadasy (1998), estimates of the long-term effective use of collaborative learning vary broadly from 10% to 93%. Collaborative learning is an effective way of learning when it is implemented well. However, much of what happens as group learning is not effective as collaborative learning. As observed by researchers in the UK, (Galton et al., 1999), in the majority of classrooms, students sit in groups, but very rarely work as groups to complete collaborative learning activities. This besg the question as to why practitioners do not implement collaborative learning activities in their classrooms, even though there is good evidence about their effectiveness.

Implementation of an educational innovation is very often challenging and meets with limited success. It is therefore not very surprising that practitioners do not often implement this approach. Nonetheless, it is important to boost the application of innovative practices, such as this, that have been shown to be effective in Education. The extent to which practitioners implement an educational innovation is a complex topic with factors from multiple levels influencing the teachers' decisions. Prior studies have investigated some of these aspects. For example, Briscoe (1991) identified the association between the innovation and the teachers' philosophy of education as an important factor; Ohlhausen, Meyerson, and Sexton (1992) identified the importance of teachers' self-efficacy in the adoption of educational innovations, whereas Fullan (1997)

discussed the significance of the school culture and the influence of principals. In addition, to these practical constraints including the availability of materials, time and space requirements are identified as significant factors (Sleeter, 1992). With the purpose of studying these factors in their study Abrami *et al.* (2004) devised a questionnaire with the aspects of value (how highly a teacher values an innovation), effectiveness (how successful a teacher expects an innovation to be), and the cost (how high a teacher perceives the costs of an innovation implementation to be). This research identified that the expectancy of success was the most important factor in differentiating teachers who implement the educational innovation and those who do not. In order to increase the likelihood of widespread implementation of an educational innovation, including those involving collaborative learning, what features of existing practice meets the teachers' and experts' expectations of success should be addressed. Therefore, in this study, the main research question we are investigating is: *what are the common features of innovative collaborative learning practice that is likely to be effective for learning from experts and practitioners' perspectives?*

A working definition of educational innovation

In this paper, we refer to the collaborative learning activities that we investigated as educational innovations. Innovation is defined as "a new method or idea or product" in dictionaries as a term. However, innovation as a fundamental cognitive schema underpinning various ideas that relate to this newness is notoriously hard to define. In their review of the literature Edison, Bin Ali, and Torkar (2013) found 41 different definitions of innovation as a concept. The authors identify certain key aspects of innovation including those relate to the impact of innovation, types of innovation, degree of novelty, innovation activities and the nature of the process of innovation. The key message given regarding innovation is that innovation is not only about the generation of new ideas but, as importantly, about the effective implementation of new ideas. Innovation does not necessarily refer to the change of the things that we do and in the ways we do them, yet it explicitly refers to *improving* the things that we do and the ways we do them. Hence, for a practice to be innovative it is not enough for it to be *new and exciting*, in addition it has to be *promising* for successful implementation. While a novel device is often described as an innovation, in economics, management science, and other fields of practice and analysis, innovation is generally considered to be the result of a process that brings together various novel ideas in a way that they affect society (Luckin et al., 2012). In this paper, all collaborative learning practice examples we have investigated were considered as promising to be successful in terms of its implementation in actual classrooms. Therefore, they are defined as educational innovations.

Literature review on the common features of effective collaborative learning

It is extremely difficult to isolate the precise nature of the key factors that in general impact on the effectiveness of collaborative learning. Of course, it is possible to identify factors within particular individual studies for which there is evidence of their impact on the collaborative learning process and output, but once one looks beyond individual studies, the situation is far more complicated. However, it is still important to briefly mention the emerging features from discussions regarding the evidence of effective collaborative learning. Looking at the existing literature on collaborative learning, we find that researchers have examined a wide range of characteristics that may make collaboration more likely to take place (Blatchford, Kutnick, Baines, & Galton, 2003). These include elements that concern the:

- Environment in which collaborative learning takes place;
- Composition, stability and size of the group;
- Knowledge, attributes, skills and attitudes of group members;
- Social, communicative and group based skills of members;
- Nature and structure of the task and how it relates to what has come before;
- Educational systems and framework in force;
- Role of adults in strategically planning for and setting up collaborative activities and how they engage with and facilitate groups aiming to collaborate.

Figure 1. Key Elements of Collaborative Learning.

Early research by Deutsch (1949) highlights *positive interdependence and promotive interaction* as central aspects for successful collaborative learning. Over the years, additional elements have been suggested to form a set of 5 features considered as essential for successful collaborative learning (Luckin *et al.*, 2017). All of these features are studied in the literature and have been shown to have impact on the effectiveness of the collaborative learning activities. Similarly, most of these features are also studied at meta-review levels.

1. Group members must be positively interdependent. This means that the task cannot be successfully completed by one person alone, but all group members must recognise that they all need to synchronise their efforts;
2. Group members must engage in *promotive interaction* and show a willingness to support each other in their joint efforts to complete the task and achieve the goal;
3. Group members must be *individually accountable* – they must make sure that they undertake their share of the work and feel personally responsible for the group's success in completing the task.
4. I*nterpersonal and group skills need to be developed*. We cannot assume that people, children in particular, naturally have the skills to participate in collaborative learning and promotive interaction – thus these skills need to be developed such that they are of a high quality.
5. Groups participate in *group processing*. This involves members reflecting on the quality of their working relationship and seeking to improve this through personal and joint effort.

Effective collaborative learning when considering teaching as a design science

In the theoretical sciences, evidence regarding the effectiveness of interventions, including educational innovations, often comes from meta-analyses of research. However, these meta-analyses present what is a rather simplistic view that we can isolate particular variables and thus, potentially discover the 'key' factors that work or serve to enhance achievement. However, more recent views about teaching stresses on the value of considering teaching practices as part of a design science similar to engineering, computer science, or architecture rather than considering it a theoretical science such as natural sciences (Laurillard, 2013). Considering teaching practices such as collaborative learning activities as a design science highlights the importance of a multidimensional and complex view of teaching, and in our case the practice of orchestrating students' learning together (Blatchford et al., 2003). Most factors that have an impact on the effectiveness of an educational innovation are interconnected and need to be considered in a *strategic* manner by teachers to identify the most relevant combination for the particular persons and circumstances at that time.

Similarly, the success of working together also depends on how teachers and other adults strategically organize these activities, how they set up the tasks, and how they engage with and support groups engaged in collaborative learning. If a teacher adopts an approach that is directive or that undermines the value of the group work, then the group is less likely to function in the desired way. This emphasizes on the value of considering teaching as a design science rather than a theoretical science. As argued by Laurillard (2013, p.1) "Teaching is not a theoretical science that describes and explains some aspect of the natural or social world. (It's)… imperative is to make the world a better place: a design science." Clearly as other design sciences, teaching leverages and contributes to theoretical science. However, when research has particular focus on supporting practitioners, considering teaching practice as a design science might generate more meaningful results. One of the main reasons behind this improvement in value for practitioners is that in design sciences process evaluations are often strongly emphasized. This does not mean that the outcome assessment is not appreciated, however, the more holistic evaluation of the design process regardless of the outcome produced is equally appreciated. Similar to the arguments relate to assessment of and for learning (Stiggins, 2005), the approach of process evaluation is often argued to be more meritorious in design sciences (Simon, 1969). This is mainly due to the arguments that the value of design activities is in autonomy, the context, the synthesis of relevant

multidisciplinary knowledge with social and cognitive skills (Seery, Canty, & Phelan, 2012). However, measuring such a complex and iterative process is very challenging with rigid assessments and abstract criteria. Rather, it requires a flexible model of assessment that relies on holistic judgement and professional experience.

In the context of judging students' design work, Kimbell (2012) outlines a new approach based on the Law of Comparative Judgement (Pollitt, 2012). The approach uses an adaptive comparative judgement (ACJ) model of assessment where comparisons of students design work with overarching criteria and professional judgement of assessors. In this paper, we use ACJ to assess collaborative learning practice examples with the purpose of identifying the most common features of those teaching practices that are considered effective collaborative learning innovations by experienced academics and practitioners. These 'judges' are considered to have an understanding of what is better or worse in terms of the required capability to implement an effective collaborative learning practice based on their expert knowledge and experience.

Preparation of the collaborative learning practice examples for ACJ

In order to help us describe and classify different types and examples of collaborative learning in a systematic level, we used a taxonomy approach to the concept (Cukurova, Luckin, Baines, 2017). This taxonomy was created for collaborative problem-solving and is informed by research and practice reviews of collaborative learning. The taxonomy has six non-hierarchical, inter-connected domains Technology, Characteristics of the collaborative problem-solving, Abilities of the participants, Group Features, Problem Features, The contextual factors. Further information about the taxonomy and its each taxonomic unit can be found in Cukurova, Luckin, & Baines, (2017). Here, we used the taxonomy to describe our 80 practice examples of collaborative learning. The taxonomy was broad enough to accommodate all the examples we have identified. Each practice example was described by a brief narrative and an ID card that summarised the example with reference to the taxonomy (illustrated in table 1). Then, these examples were used as in the adaptive comparative judgement process (ACJ).

Collaborative learning activity ID1:

Students in pairs attempt to solve what a fictitious animal species would look like after evolution had occurred using a computer simulation. Students are assigned random features of the alien planet that could put evolutionary pressure on the alien. Then, they are asked to draw what they think the animal would look like. Students work in mixed age groups, and are not provided specific instructions on how to collaborate, or how to problem-solve.

Table 1: Collaborative learning practice example and its taxonomic representation adaptive comparative judgment of collaborative problem-solving practice

Characteristics of CL	• One-off activity • Development of participants' skills are not explicitly targeted
Group composition	• Pairs of mixed aged • Mixed gender groups • Participants act synchronously in medium acquaintance groups
Problem characteristics	• STEM domain • Medium complexity, authenticity, and outcome of the problem • Low social interdependence of participants
Contextual characteristics	• Tertiary education • School laboratories • Participants in the same physical space and taking actions in a digital environment • Participants are monitored individually
Use of technology	• Computer simulation

Table 2 illustrates that most examples used in the study were one-off activities and only 1 of the examples could be identified as being part of a programme of collaborative learning (CL) activities. In almost half of the examples the CL process itself was not evaluated, although it was monitored. There was more evidence of CL being evaluated with the group as the unit of analysis (37.5%) than with the individual learner as the unit of analysis (15%), and more evidence of skills in the social domain being the focus of development could be

identified (26.25%) than examples where the problem solving itself was the focus for development (13.75%). The teacher was identified as the leader of reflection in 31.25% of examples and the group was identified as the leader of reflection in only 10% of examples, illustrating the significant role that teachers play in CL practice.

Table 2: Frequency of innovative CL practice examples' taxonomic characteristics

Category Name	Practice Example Total Number in this Category	% of Practice Example in this Category
One-off activity	**79**	98.75
CL not evaluated but monitored	**39**	48.75
CL evaluated as a group	**30**	37.5
Teacher-led reflection	**25**	31.25
Development of skills explicitly targeted in social domain	**21**	26.25
Technology is employed for CL	**19**	23.75
Development of skills explicitly targeted in both social and problem-solving domain	**16**	20
Cross curricular CL activity	**16**	20
Group roles are allocated	**14**	17.5
CL evaluated individually	**12**	15
Development of skills explicitly targeted in problem solving domain	**11**	13.75
Group-led reflection	**8**	10
Single gender grouping	**1**	1.25
Programme of activities of CL	**1**	1.25
Group ethos addressed part of the CL activity	**1**	1.25

Adaptive Comparative Judgment of collaborative learning practice examples

The narrative descriptions and ID cards for all 80 collaborative learning practice examples were used for the ACJ process with members of our expert panel. The software used for the process was online and it presented two practice examples simultaneously and asked experts to pick one of them. The aggregation of these judgements across collaborative learning activities produced an order of the activities from what was judged as the most likely to be effective innovative practice example to the least likely. The precise instructions given to the experts were:

> *"Please read the examples and compare each of the two examples of collaborative learning activity that are presented to you and decide which of them is the best example of innovative practice that is likely to be effective for learning."*

Thirty-six experts completed the online ACJ task. The first five rounds of the comparisons were non-adaptive "Swiss Tournament" rounds to create a rough sort. After the fifth round, the algorithm of the online software becomes adaptive and starts presenting those examples, which are closely ranked at the previous round in order to increase the reliability coefficient.

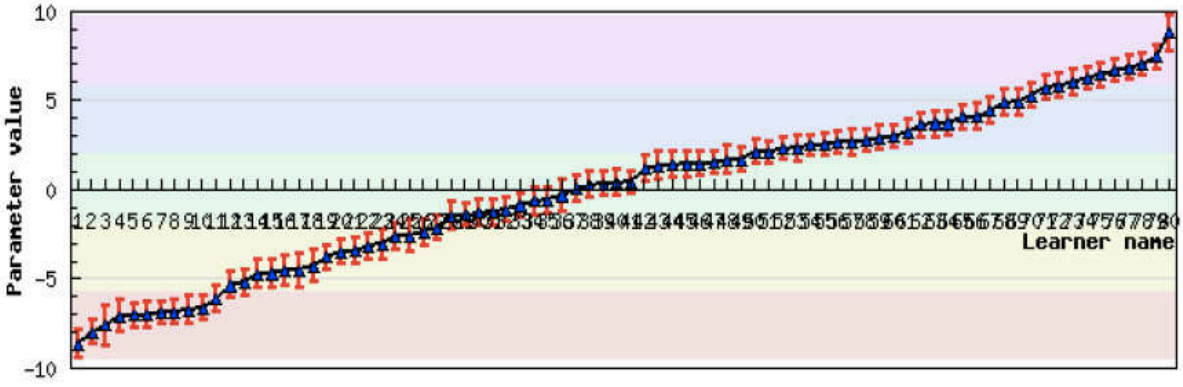

Figure 2. Parameter value error plot.

Results of the ACJ

The ACJ process was completed by 36 members of our expert panel (11 experienced teachers and 25 experienced academics from the learning sciences). The top 3 examples along with associated expert comments are illustrated in Table 3 and one can see that all three explicitly targeted the development of social skills. Two of the top three examples were from secondary schools and the other one was from a primary school. All three took place in classrooms and involved mixed gender groups of mixed ability.

Using the parameter values of each practice example of CL in the ranking list emerged as the result of ACJ process, we created the table 3 below. It shows the relative importance size of the categories of practice examples based on parameter values of the practice examples. These values were calculated by adding the parameter values of the practice examples' taxonomic unit features. As can be seen, the most important features of innovative and likely to be effective for learning CL practice examples for expert opinion were: monitoring of the CL practice rather than evaluation of it, technology used in the practice activity, whether the activity targets to develop skills in both social and problem solving space and whether the activity provides opportunity for reflection (see table 3).

Table 3: The Importance of Particular Categories of Example for Experts' Evaluation

Categories relative importance order		Relative importance size
1	CL activity is monitored not evaluated	56.4
2	Technology is used to facilitate CL	32.7
3	Development of skills targeted in both social and PS space	28
4	Teacher-led reflection	25.5
5	Group-led reflection	23.7
6	CL is evaluated individually	19.3
7	Group ethos are addressed	7
8	Development of skills targeted in social domain	3.5
9	Programme of activities	2.7
10	Single gender grouping	1.4
11	Development of skills targeted in problem-solving domain	-0.6
12	Group roles are allocated	-2.7
13	CL evaluated as a group	-2.8
14	Cross curricular activity used in CL	-19.9

Table 3 was created using the sum of parameter values of each CL practice example. On the other hand, Table 4 illustrates the importance of key categories in the ACJ process and it provides information about the language that most frequently graced expert feedback. The feedback from experts indicates the aspects of the CL examples that experts focused upon in making their judgements. Although there is no particular mention of the evaluation aspect of in experts' qualitative feedback, the other characteristics of CL practice and their relative importance rankings show great amount of overlap.

Table 4: Experts' Most Frequent Feedback

The most frequently mentioned aspects in feedback	Number of mentions
Technology	16
Contribution to students' discussion	16
Contribution to students' reflection	15
Authenticity of Problem or Task	14
Interdependence of Participants	12
Appropriate feedback provided for students	11
Contribution to CL skill development	11

The last three activities in rankings of the CL practice were all STEM activities in secondary or tertiary education. In contrast to the positive feedback from experts, the reasons experts gave for deciding these practice examples as neither being innovative nor effective were often about the lack of interdependence of students, lack of support provided to students for their development of social and problem solving skills, and the type of the problem tasks provided to students not being appropriate for providing opportunities for interactions among students and discussions.

Discussion and conclusions

The expectancy of success is an important factor in differentiating between those practitioners who do implement an educational innovation and those who do not (Abrami *et al*., 2004). Therefore, all educational innovations must justify their existence with some type of evidence of their effectiveness. As presented in the introduction and literature review sections, there is substantial evidence on the positive impact of collaborative learning on achievement and attitude, and that it can be more motivating than more traditional approaches to instruction. However, there is also evidence that collaborative learning is often poorly implemented. This may be because neither collaborative learning is something that students are naturally familiar with and good at completing, nor teachers are appropriately equipped to implement it. Research literature provides practitioners with some elements that are found to be present when effective collaborative learning happens, yet inevitably such reviews of meta-analyses present a rather simplistic view which encourages practitioners to think that particular variables can always be isolated and implemented. This approach to effectiveness is highly appropriate for theoretical sciences, yet their value for design sciences, in which implementations are considered as dynamic and flexible rather than as ready-made solutions, may not be equally pertinent.

There is no question that collaborative learning is anything other than complex, with multiple factors interacting and impacting upon the manner in which the collaborative process takes place. Therefore, adoption and implementation of collaborative learning approaches in teaching practice may be better supported if teaching is regarded as a design science (Laurillard, 2013) through which teachers paid attention to the design of the collaborative learning process in a systematic manner. This is not to say that evidence generated regarding the effectiveness of educational innovations from different methodologies is not valuable. However, the suitability of the proposed evaluation methods and the types of evidence should be the focus of attention on innovation evaluations (Cukurova, & Luckin, 2018). If judged by the criterion of usefulness to the practitioners, considering teaching as a design science may have greater advantages.

In this paper, we discuss a research-informed taxonomy of collaborative learning (Cukurova, Luckin, Baines, 2017). This taxonomy was used to categorise eighty proposed innovations in collaborative learning. These eighty innovations were then judged by a panel of thirty-six learning sciences experts drawn from academia and educational practice. A software, which is designed to adjust presented examples based on judges' responses, was used to present each judge with a selection of innovations each of which had to be judged against another. The experts were asked to select from each pair, the innovation that they thought most likely to be effective. Most examples judged were one-off activities and only one of the examples could be identified as being part of a programme of collaborative learning activities. In almost half of the cases, the collaborative learning process was not evaluated, and when a potential innovation has been evaluated there is a tendency for this to have been conducted at the group level, rather than interns of each individual learner. As we have completed our crowdsourcing of the practices broadly in the UK and included some from other English-speaking countries (USA, Australia, and Canada), we expect that this landscape reflects the general practice.

The results of the ACJ process show that the most innovative and expected to be effective collaborative learning activities are those that are monitored but not formally assessed. The use of technology was a feature that was often present within innovations that are judged to be potentially effective. Moreover, the extent to which an innovation included an activity that was targeted at developing both problem-solving and social skills of students, was also considered as a significant feature for innovative collaborative learning activities that are likely to be effective. An analysis of the feedback provided from members of our expert panel revealed a consistency. Experts valued innovations that require students to discuss and reflect upon authentic problems and tasks, and to receive appropriate feedback about their progress.

This paper presents the ACJ process combined with a taxonomy to categorize across a range of potential collaborative learning innovations, as an alternative way to evaluate the common features of educational innovations that are expected to be effective. Although, we address collaborative learning innovations here, we hope that the approach exemplifies an alternative for evaluating educational innovations more broadly. We argue that the approach might be particularly appropriate when it is not practical to conduct empirical evaluations of the innovations under consideration.

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