2020 cohort

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Lesson compaction in post-16 Physics

Introduction and problematization

In post-16 Physics lessons in my school context, there is often a wide range of prior attainment, a proxy for relevant prior knowledge. For students with strong prior knowledge, listening to a re-exposition of securely learned content is unlikely to be the best use of lesson time and could disincentivize independent preparation for lessons (Goedhart, Blignaut-van Westrhenen, Moser, & Zweekhorst, 2019). Meanwhile, the same teacher-led exposition could be excessively challenging for a pupil with weaker prior knowledge, due to the greater demand on limited working memory (Sweller, van Merriënboer, & Paas, 2019), suggesting strong potential benefits of a differentiated approach.

'Curriculum compacting' was first proposed and named in the context of Gifted and Talented education, as a way of enriching the educational experiences of gifted children while reducing the potential for boredom and frustration (Renzulli, Smith, & Reis, 1983). In the original concept, pupils are selected by pre-course testing to skip some regular timetabled lessons and complete enrichment or extension activities instead. I investigated the compaction concept in post-16 Physics lessons, but using a lesson-by-lesson implementation rather than at the level of whole units of work, to enable a timely assessment of the relevant prior knowledge and avoid potential long-term labelling of pupils as higher or lower ability. The feature defining a lesson as 'compacted' in the study was that students could skip a portion of teacher-led content exposition or routine practice tasks in favour of independent work on more challenging question sets, based on the results of a prior knowledge test (pre-test) at the start of the lesson.

Intervention and data collection

The overarching research question of the study was "In what ways can compacted lessons benefit post-16 Physics students?". I addressed the question through a small-scale qualitative study in an action research design. I taught several compacted lessons with my year 12 class, and held semi-structured interviews with student participants after the final lesson in the study. I resourced three additional lessons for two teacher participants, one for each of their A-level classes, and held semi-structured interviews with each teacher participant shortly after they had taught their compacted lesson(s). The semi-structured interviews were used as the main source of qualitative data, supplemented with students' responses on an initial questionnaire and short in-lesson reflection tasks, and with natural data in the form of students' work on the independent tasks.

Findings

Both student and teacher participants responded positively to the pre-test in and of itself, independently of any subsequent differentiation of the lesson. A major benefit of the pre-test is the nature of the feedback it provides. Different ways of addressing the various possible fine-grained outcomes of the pre-test are built naturally in to the lesson structure, especially in terms of responding in different ways to identified knowledge gaps, mistakes and misconceptions. In the case of knowledge gaps, further instruction rather than feedback is recommended (Hattie &

Timperley, 2007), which is already part of the compacted lesson strategy. In the case of misconceptions, where simply stating the correct answer as feedback is unlikely to be effective (Black, Harrison, Lee, Marshall, & Wiliam, 2004) the degree of overlap in students' responses can indicate to the teacher a situation where a group or whole-class discussion of the misconception would be helpful, which was the approach taken by one of the teacher participants. Further, the compacted lesson structure provides an automatic opportunity for feed-forward, the application of feedback to a related task (Shute, 2008).

Initially, a rigid cutoff score from the pre-test was used to assign students to the independent work. However, student feedback and the decisions taken by teacher participants, considered in the framework of the self-determination theory of intrinsic motivation (Deci & Ryan, 2000) suggest strong benefits to a more flexible approach. Allowing students to self-select for the more challenging independent task is expected to sustain their intrinsic motivation if their choice is connected to their personal goals in line with autonomy support, and if the choice is informed (by the pre-test) and manageable (e.g. here, binary) in line with competence support (Katz & Assor, 2006). Allowing students to move up to the more challenging task after a proportionate amount of corrective work or routine practice based on the pre-test could avoid the perception of an unfair consequence for mistakes and reinforce students' general attitude to the pre-test as a chance to show competence rather than a way to access a reward. Additionally, both sets of participants described benefits of collaborative group work, which in the smaller class (year 12, class of 4) implies a default preference to avoid a task split, and more generally suggests that personalization of the independent task through question choice is likely to be unproductive.

Students viewed linking different items of knowledge as a key source of value gained from practicing exam-style questions in the independent tasks. The literature on problem-solving in Physics supports the idea that making links in knowledge is an important part of making progress, by building up progressively more complex connected chunks of knowledge that can be manipulated as single items, allowing complex problem-solving without working memory overload (Tuminaro & Redish, 2007). Within hierarchies of problem demand, the value of linking and organizing knowledge could be thought of opening up lower-demand routes to solving a similar problem in future, for example in the Physics Problem-Solving Taxonomy (Shakhman & Barak, 2019) a strategy-level problem could be turned into a retrieval-level problem. Students' classwork showed that even nominally low-demand questions can provide this type of benefit, as they may be solved by higher-demand routes if students do not initially recognize that a lower-demand solution is possible.

Teachers felt that question sets for independent practice could be efficiently assembled out of past A-level exam questions. There was no sense from student or teacher interviews that past exam questions provided insufficient challenge, possibly reflecting the remit of A-level exams from 2008 onwards to provide stretch and challenge to the highest attaining pupils (Department for Education and Skills, 2005). Additional preparation time associated with atomizing more synoptic problem sets associated with stretch and challenge (Isaac Physics, BPhO Senior Physics Challenge) was not reflected in any clear benefits to students. However, 'conceptual' questions requiring an answer or explanation in terms of underlying physical principles rather than explicit calculation, did not add much to the time needed to resource the lessons, added considerable challenge for students, and were appreciated by teacher participants.

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