How can Mastery learning promote inclusion in the science classroom?

Mastery learning is not a new concept as it has been around for many years and will continue to feature in the educational scene as educators explore how it can be utilised to promote learning, despite the varying views regarding its impact on pupils' learning and progress. The purpose of this article is to amplify the concept of mastery learning and its place in promoting inclusive learning among science pupils and highlight reasons why this pedagogy should be considered by science teachers.

What is mastery learning?

Bloom (1971) defines mastery learning as a pedagogy that helps pupils to retrieve previously taught content and retain it for a longer period. McIntosh (2015) considers mastery learning as a specific approach in which learning is broken down into discrete units and presented in logical order. Guskey (1997) and Bloom (1971) suggest that mastery learning is more effective when learning aims are structured to provoke high-order thinking, and the teacher should create the environment to enable and facilitate learning. This suggests that both teachers and pupils should understand the learning objectives and how to meet them through utilising the relevant assessment for learning strategies. However, this may require time to achieve as pupils will need to internalise the process to achieve mastery in their learning.

Mastery learning helps teachers to know when to progress their lessons and pupils' learning. McIntosh (2015) identifies the following steps for mastery learning: initial learning, formative assessment, corrective activities and enrichment activities. Guskey (2010) argues that as teachers strive to improve pupils' achievement, they should embrace the core elements of mastery learning in their teaching and we have presented these elements in table 1 to guide teachers as they consider this pedagogy. Mastery learning helps pupils to demonstrate mastery of each unit before moving on to the next and they should be given support by teachers (McIntosh, 2015).

The rationale for mastery learning

The performance of year 9 pupils in England has significantly declined since 2015 as reported in the Trends in International Mathematics and Science Study (TIMSS) (Richardson et al., 2020). Pupils in year 5 performed better in science in 2015 than they did in year 9 in 2019. This was due to a strong cognitive domain in year 5 but weaker when these pupils were in year 9, and with a wider gap between the highest attainers and the lowest attainers. Although it should be noted that the performance of pupils in England was above the baseline set by TIMSS however, more is required to bring pupils in England at par with their counterparts from other countries. Ofsted (2021) reflected similar findings for pupils. There are many reasons why pupils may underperform. This may include increased academic rigour in the subject content and the increased emphasis on written examinations (Maguire, Gewirtz, Towers and Neumann, 2019), the lack of differentiated learning opportunities to promote inclusion for the different needs of pupils. Following up with curricula contents, the sciences have heavy course contents and this may hinder pupils' progress due to time constraints to master their learning. That is why we advocate for a carefully planned sequence of mastery learning, and this will be discussed in the section on ‘classroom practices that promote mastery learning’ and a summary in table 1.

In English primary education, the teaching time allocated to the science curriculum is lower compared to other countries; 1hr 24 minutes on average per week compared with 2 hrs per week in other countries (Stubberfield and Barton, 2021). The emphasis in England is on maths and English subject areas, especially for lower year groups due to the emphasis on the SATs exams at the end of year 6 in these subject areas. Although it should be noted that the time allocated to teaching science had increased in early 2020, the Covid-19 pandemic has led to a decline (Stubberfield and Barton, 2021). Possible reasons could be schools giving more time to catch up on subjects such as maths and English.

Educators have been clamouring for improvement in science teaching in primary school to help pupils develop relevant conceptual knowledge of science as they transit into secondary school, a view that is corroborated by Ofsted (2021) who emphasises that pupils should be provided with secure foundational knowledge in primary school to build upon in secondary school. This is to enable pupils to develop a conceptual understanding of the deep structures and connections across other topics and subject areas. Therefore, as the accountability systems of primary education drive this lack of emphasis on science education or investment in additional time, secondary education needs to look carefully at teaching strategies to support teachers in identifying and addressing gaps in scientific knowledge. We would suggest adopting mastery learning as part of the means to support this process but may not be exhaustive as it can be used with relevant learning theories to support pupils.

Ofsted (2021) conclude that if gaps in pupils’ knowledge are not addressed earlier in primary education, this will hinder their progress as they go into secondary education. Ofsted identified the following areas to promote successful high-quality teaching:

- scientific knowledge needs to be carefully sequenced so that fundamental knowledge around key scientific principles such as photosynthesis, magnetism and substances is threaded throughout the curriculum. These big ideas of science in addition to others need to be interwoven throughout the curriculum (Harlen, 2010).
- the interconnectedness of scientific disciplines (biology, chemistry and physics) needs to be explicit to allow for knowledge development.

The above links closely to the National Curriculum for Science (DfE, 2015) and with the teaching aims that ensure all pupils:

- develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics
- develop an understanding of the nature, processes and methods of science through different types of science inquiries that help them to answer scientific questions about the world around them
- are equipped with the scientific knowledge required to understand the uses and implications of science, today and in the future.

Mastery learning and inclusion

A high-quality curriculum promotes inclusion by meeting the needs of all pupils and teaches the knowledge required to participate in the learning process. An ambitious curriculum will promote inclusive learning ensuring pupils have equal access to content that does not impose an artificial ceiling on what they can achieve. For example, pupils with SEND are not a homogenous group and providing different activities for them without adequate consultation and understanding of their specific needs can predetermine what each pupil can achieve. Pupils themselves can provide much-needed expertise on their own needs. Specific adaptations of contents might be required but effective curriculum planning should begin with diverse access arrangements in mind. Could mastery learning be useful to support such pupils and promote inclusion, we think it would.

The difficulty with mastery learning lies in its delivery, teachers' expertise, the burden on teachers and the contents presented for learning. Therefore, leaders and teachers should plan fully for inclusion and recognise that adaptations might be required for some pupils. The challenges for teachers in a class with pupils having different learning needs centre on identifying how to meet the individual learning needs effectively (McIntosh, 2015). Mastery learning could be useful in supporting pupils' learning needs and we will discuss this in the next section. For example, the EEF (2021) suggests that mastery learning is an effective tool in improving learner outcomes by six months or more in science and mathematics. Other international studies such as Guskey (2010) assert that mastery learning has a positive effect on pupils' learning and progress and Mitee and Obaitan (2015) conclude that it enhances the cognitive learning outcome of secondary school pupils in quantitative chemistry. They attribute pupils' performance to the teacher, teaching methods and materials used.

Classroom practices that promote mastery learning

In this section, we will discuss two approaches to mastery learning that can promote inclusion as they afford pupils opportunities to work at a different pace.

Approach one

The first approach to mastery learning by Barton (2018) discusses the role that cognitive science plays and how pupils think and learn as well as the significance cognitive load theory holds for mastery learning. The cognitive load theory enables teachers to scaffold learning to help pupils acquire the foundational knowledge of a concept and this can reduce any unnecessary load on their working memory making it easier for pupils to focus on the specific skill and concepts being taught. Barton (2018) postulates that teaching practices that underpin mastery learning include diagnostic assessment, direct instruction and teacher-led strategies.

The teacher provides direct instructions by breaking down or chunking the learning into smaller components and explicitly teaching a particular skill set. The teacher draws the pupils to what they want them to notice. In essence, this can reduce the load on the working memory and help pupils to recall information. It also improves their meta-cognitive skills and aid in organising their knowledge into schemas, thus enabling them to apply this learning to new concepts and aid mastery. Mathematics has a long history of using mastery learning and the strategies used are associated with cognitive science such as retrieval practice, spacing and interleaving.

Spacing allows a gap between the initial learning episode and the revisiting of this learning. This ensures that pupils can be tested to assess what they have learned and how they can apply the concepts to new situations (Barton, 2018). Interleaving can be used in science classrooms. It involves questions being interspersed with questions of a similar nature. For example, interleaving questions can be selected from topics in biology, chemistry and physics. This can aid pupils' understanding of concepts of a similar nature.

Approach two

The second approach to mastery learning by Bloom (1971 p.3) suggests supporting pupils by incorporating progress checks as part of the learning process and not necessarily at the end of unit tests. The assumption is that it would allow teachers to relay feedback and corrective measures to assess learning, and the opportunity to redo similar progress checks until pupils master their learning. Bloom's steps in promoting mastery learning include:

- Teachers organise the concepts and skills they want pupils to learn into instructional units that typically involve about a week or two of instructional time.
- Following an initial instruction on the unit, teachers will administer a brief formative assessment based on the unit's learning goals to give pupils information and feedback on their learning.
- The feedback helps to close gaps in pupils learning by identifying what they can and cannot do.
- Provide pupils with corrective activities to correct their learning difficulties so they can work on those concepts or skills not yet mastered
- Identify alternative learning resources to support pupils such as computers, videos and enrichment activities.
- After completing the above steps, pupils take a second formative assessment (Guskey, 2010). This assessment is like the first, but it has slightly different problems or questions to verify previous learning and give pupils a second chance at success and boost motivation.

Both methods of mastery learning show that the teacher is pivotal to the progress that pupils can make, and we can infer that although it is a teacher-led pedagogy, at the heart of the process is promoting pupils' learning with the view of helping them to become autonomous learners. Therefore, combining the steps from both authors has been useful for us in designing a guide for classroom teachers to help with mastery learning, see table 1 below.

Conclusion

Mastery learning is achieved through careful consideration of how cognitive science can inform the structure and delivery of the curriculum to promote inclusion for all pupils to meet their learning goals. Furthermore, the cognitive strategies used to reinforce and improve learning outcomes are not just restricted to maths and science lessons but can be used effectively in all subject areas to improve pupils' outcomes. Mastery learning is more developed in maths than science education and this makes this article valuable in highlighting mastery learning as having a pride of place in science education. Therefore, we believe that this contribution will further resurrect any issues and neglect regarding this method of teaching and learning. At the same time spur science teachers to embrace it in their classrooms or incorporate it with processes such as Rosenshine's principle of instruction and other learning theories.

Table 1: Mastery learning process

<table>
<tr>
<td rowspan="4">Teacher instruction + Focused learning objectives

Teacher correction</td>
<td>Retrieval practice

Combination of questions from last week/last month/ last term</td>
<td>Outcomes of retrieval practice:
-reduced cognitive load
-time to master new materials
-identify gaps in pupils’ knowledge/adjust class size
- targeted support
- long term memory</td>
<td rowspan="5">Re-test with questions/quizzes, exam questions for mastery

To confirm gaps are closed- retest pupils</td>
<td rowspan="5">Pupils can be regrouped for differentiated learning purposes
+
Teacher feedback Interleaving tasks</td>
</tr>
<tr>
<td>Questions, quizzes, targeted exam questions.

Interleaving tasks- random questions from biology, chemistry and physics and any links.</td>
<td>Spacing/revisiting learning

+

Time-bound</td>
</tr>
<tr>
<td>Formative assessments

Feedback- oral/written Corrective measures from teachers’ assessment

Promotes mastery learning</td>
<td>Pupils’ corrective measures
Self and peer Assessments, collaborative learning- teacher approval/guidance

Promotes mastery learning</td>
</tr>
<tr>
<td colspan="2">Mastery achieved- move on to new task (from final assessment/ summative)</td>
</tr>
<tr>
<td>Gaps in learning</td>
<td colspan="2">Mastery not achieved, address gaps in learning

Gaps in learning are closed by using alternative means such as enrichment activities, computer learning, differentiated learning strategies and tutoring.
Boost motivation and promote mastery learning.

Corrective process, time/ learning environment</td>
</tr>
</table>

Teacher instruction **Mastery learning for Inclusion** Time

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