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Research FOCUS

Nurturing socio-economically challenged learners' curiosity in chemistry

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Editor's note:
It is highly unusual for *EiS* to feature two articles about the same item, but on this occasion we were offered an article about Liverpool John Moores University's Chemistry for All initiative (see pages 26 and 27), along with this second piece with more detail about the research behind the project, which has been submitted through the ASE Research Group. We hope that you find them both mutually informative!

It is understood that 'active learning', in which students participate in their own learning, is effective in developing understanding (Michael & Modell, 2003). Students are likely to engage well in lessons that require participation and that challenge them to develop their understanding through hands-on experience (Koballa & Glynn, 2007). Learning outcomes are enhanced when enjoyment is high. This has been a cornerstone of Liverpool John Moores University's programme of interventions delivered for the Royal Society of Chemistry project, *Chemistry for All* (*CfA*).

Why do we need enhancement?

Students in secondary school like to do practical experiments (Wellcome Trust, 2017). Hands-on learning seems to excite and enthuse learners and enable them to see science in context. There is a large body of research that describes the impact of active learning on student enjoyment and outcomes (Gutwill-Wise, 2001; Avery Gomez *et al*, 2010). Learners from low socio-economic backgrounds are likely to do less practical science than those from affluent backgrounds and are also less likely to study science post-16 (Sutton Trust, 2017). The CfA project aim is to increase inspiration in secondary science students by providing stimulating sessions and, working with the Institute of Education, to understand the barriers to pursuing science for this demographic (Mujtaba *et al,* 2018).

The Chemistry for All Programme

Chemistry for All (2014 -19) is a 5-year longitudinal research programme funded by the Royal Society of Chemistry (RSC) to support university-led intervention activities in schools. As part of this research programme, Liverpool John Moores University (LJMU) works with local secondary school students from socially disadvantaged areas to deliver an intensive programme of chemistry interventions. The interventions delivered are influenced by the following five key themes – ***enrichment***, ***enhancement***, ***motivation***, ***aspiration*** and ***careers***, to motivate students to achieve their potential, both in terms of science learning and in terms of long-term employability.

The programme runs for five years and targets a selected cohort of students as they progress through secondary school (age 12-17). The schools and students are chosen from low socio-economic backgrounds; schools involved have pupil premium percentages higher than the national average. Aiming to understand the barriers to entering a chemistry career for people in this under-represented group, the longitudinal nature and research aspect is a unique feature of the project. Events aim to enthuse students by enriching and enhancing their experience of the chemistry curriculum and developing their practical competency, increasing motivation for the subject. We aim to raise awareness of the opportunities provided by the study of chemistry and provide information on chemistry careers to support high aspirations (Gazeley & Dunne, 2005). The full impact of these activities has yet to unfold, but we present our initial findings from some activities on the students' views from the first two years of the programme.

The activities

Year 8 (age 12-13) pupils experience an in-school intervention called '*Chemistry in your Shopping Basket'*. There is a strong emphasis on hands-on experimentation, with students exploring pH and chemical reactions including 'King Kong's Hand'. Spectacular demonstrations include the exploding methane bubbles and the erupting elephant's toothpaste, to name a few.

Year 9 (age 13-14) pupils participate in '*Working Scientifically'* and '*Chemistry of Large Molecules'.* These events incorporate practical skills such as titration, but also include data analysis and student-centred activities such as the role play of a polymerisation reaction. The level of challenge increases as difficult chemical concepts are broken down into accessible activities. There is heavy emphasis on students performing experiments themselves; however, the activities include high expectations for numeracy and literacy, with scaffolded support (Hogan & Pressley, 1997) for students who require it.

Gala University days comprise a full day spent in the University, with an extended laboratory session (2½ hours) in which challenging exercises develop practical competency. The Year 8 '*Chemistry in your Life'* laboratory session turns pupils into 'formulation scientists', in which they formulate an ointment and examine the effect of additives on emulsions, modelling the process of adding fragrance to products such as face cream. This is followed by an engaging science show from our partners Science2U (www.science2u.co.uk). The Year 9 '*Chemistry at the Crime Scene'* is a day of forensic chemistry, in which students develop analytical and evaluative skills and see

how chemical and physical tests are used in a forensic case study. They analyse evidence to build a case to solve a 'murder'. All events provide a context for the chemistry studied and the aim is to make it relevant to the students.

How effective has the CfA project been in supporting socio-economic challenged learners?

Over the first two years of the project, 73% of the learners expressed the top level of enjoyment and 98% the top two levels. 37% thought they learned a great deal and 85% learned something or a lot. The '*Chemistry at the Crime Scene'* Year 9 event was an overwhelming success across the two years, where students indicated the only possible improvement was *more* practical activities. Considering the majority of the day was laboratory-based, we are unsure how to fit this in! One pupil said: *'I enjoyed the experiments and I learned lots of facts that will help me in the future'.*

Looking at the Year 8 satisfaction levels, once again these are over-whelmingly positive, with 'King Kong's Hand' being a major success, closely followed by 'Methane Bubbles'. Thus, hands-on practical science can really ignite a student's curiosity, even though the literacy and numeracy demands of some activities were challenging.

For Year 9, this excellent learner satisfaction is set against the context of hormonal and social changes for this age range. There was no evidence in the initial findings to suggest that there is a reduction in enjoyment or engagement from Year 8 to Year 9, despite the common developmental issues faced by students of this age, such as becoming self-aware and wishing to be 'cool' amongst peers. In addition, there was no evidence of a negative impact from variables around the design and delivery of the activities, such as curriculum design (the Year 9 session was more challenging) and school differences (the chemistry experiences in schools differing). There was also no evidence of gender separation.

Impact of the programme

CfA is a successful outreach programme, whose community engagement includes students, parents, teachers, primary students and outside agencies. CfA has significantly increased laboratory time and engagement with chemistry for the students involved. Evaluation of feedback shows that students enjoy and engage with the activities and learn from the events.

Frequently, teachers express that students whose behaviour and engagement levels are poor enjoy and participate in our activities. One teacher said: *'Students have gained a huge amount of enrichment through visiting University, and through the outbound days have experienced a large range of activities to enrich them beyond classroom experience'.*

The success of the interventions rests on the emphasis on hands-on, active learning in which students are engaged and challenged. The context is made relevant for these teenagers from deprived backgrounds and support is given where needed to enhance numeracy and literacy in a scientific context. Initial findings suggest that students exhibit increased confidence, motivation and engagement with the subject of chemistry.

The LJMU Chemistry for All team consists of Dr. Ian Bradshaw (Project Director), Dr. Linda Seton, Dr. Andrea Mallaburn, Menna Goodwin, Paul Ireland, Emma Smith and Victoria Brennan. They were supported in the design and development of the 'Chemistry at the Crime Scene' event by Dr. Amanda Boddis, forensic chemist (LJMU) and by Rick Tynan (LJMU) for his statistical analysis of the evaluation data. The authors gratefully acknowledge the Royal Society of Chemistry and Liverpool John Moores University for joint funding of the LJMU programme. Follow our activities on Twitter @LJMU_CfA

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