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An Action Research Project to Improve Teaching and Learning of Organic Chemistry in Second-Level Schools

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Background

The difficulties of Organic Chemistry have been investigated and researched in many countries. Organic formulae (Johnstone, 2006), curved arrow diagrams (Bhattacharyya and Bodner 2005, Ferguson and Bodner, 2008), mechanisms (Rushton *et al*., 2008) and laboratory classes (Greenbowe and Schroeder, 2008) have all been identified as difficult topics. Many innovative teaching programmes have been implemented effectively in other countries to alleviate the difficulties identified in Chemistry. Examples include context-based programmes (Bennet and Lubben 2006, Parchmann *et al.,* 2006) and programmes to facilitate cognitive development (Adey, 1999), amongst other initiatives.

The *ITS Chemistry* (Increasing Thinking Skills in Chemistry) programme was designed to facilitate the teaching of Leaving Certificate Chemistry in Ireland. This programme focused on the concepts of the mole and the particulate nature of matter. It was effective in improving pupils' cognitive ability and understanding of Chemistry (Sheehan, 2010).

Organic Chemistry accounts for a substantial amount of the Leaving Certificate Chemistry syllabus (20%) and examination (25%) in Ireland. However, there has been no explicit research carried out investigating the difficulties experienced by Leaving Certificate pupils in their learning and understanding Organic Chemistry.

Methodology

The project was carried out in three phases (Figure 1)**.** Phase One of the project involved an investigation at Second-Level involving Leaving Certificate Chemistry teachers and pupils. From this investigation a number of key topics were identified as difficult in Leaving Certificate Organic Chemistry: IUPAC Nomenclature, Functional Groups, Characteristics of Organic Compounds, Reaction Types, Reaction Mechanisms and Practical work (O' Dwyer and Childs, 2011).

Phase Two involved the development of an intervention programme.

Phase Three involved the implementation and evaluation of the programme in Irish Second-Level schools. The programme was trialed in 6 Second-Level schools with 87 sixth year pupils. The programme was evaluated using three lenses: participating teachers, participating pupils and comparison with a Control Group (117 pupils from 9 Second-Level schools).

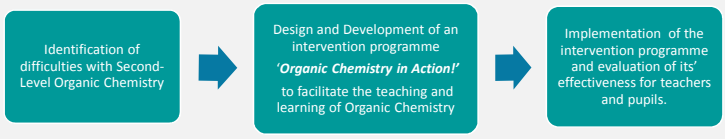

Figure 1. Three phases of the Action Research Project

Organic Chemistry in Action!

The *Organic Chemistry in Action! (OCIA!)* programme was developed using the findings from Phase One of the project and also from the relevant findings in Chemistry Education Research. The ten key design criteria used in the development of the programme are outlined in Figure 2 (O' Dwyer and Childs, 2012). The animation below (Figure 3) illustrates the importance of the use of contextual links to interest the learner when teaching Organic Chemistry. The programme was designed to cover the content of the current Leaving Certificate Chemistry syllabus (DES, 1999). Teaching and learning strategies were integrated with the design criteria with a specific focus on the relevance to the areas of difficulty that were identified by teachers and pupils in Ireland. Figure 4 below shows a photograph of some of the teaching materials prepared for use with the *Organic Chemistry in Action!* programme.

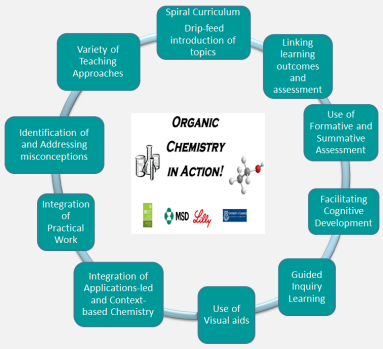

Figure 2. Design criteria for the Organic Chemistry in Action! programme.

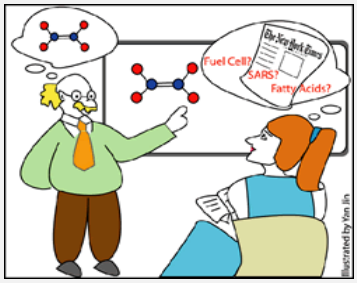

Figure 3. Animation of conflict of interest between the teacher and learner in Organic Chemistry- importance of the Context-Based Approach.

Figure 4. Photograph of the Organic Chemistry in Action! teaching materials.

Findings

The main feedback from the participating teachers is shown in Figure 5 below. The most effective design criteria are identified. Most of the teachers' concerns about the programme were issues relating to deviation from the syllabus content and concern about examination preparation.

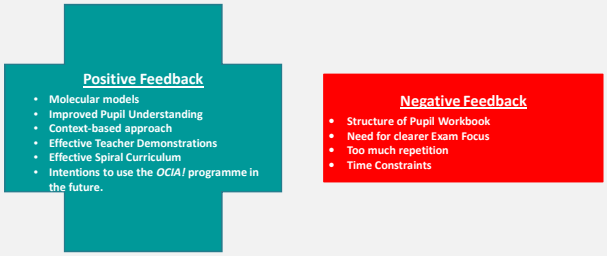

Figure 5. Summary of positive and negative feedback from participating teachers in the Organic Chemistry in Action! programme.

Due to the multi-faceted nature of the programme, it is difficult to determine which factor(s) contributed most to the improvement in pupils' attitudes, interest and understanding of Organic Chemistry.

The *Organic Chemistry in Action!* programme had a significantly positive effect on females as well as on pupils who had studied Higher Level Junior Certificate Mathematics and those studying Higher Level Leaving Certificate Chemistry.

The pupils in the Intervention Group and the Control Group were given the same Organic Chemistry Test for Understanding. The performance of both groups is shown in Figure 6 below. The Control Group of pupils had a stronger background in Science and Mathematics from their Junior Certificate. Despite this, the pupils in the Intervention Group performed better (median score= 49.00%) than the pupils in the Control Group (median score=44.75%) in the Test for Understanding.

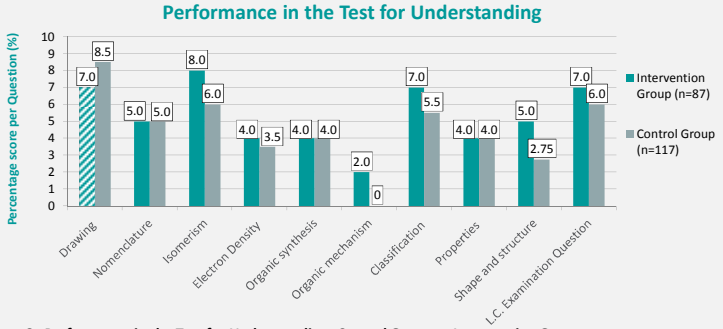

Figure 6. Performance in the Test for Understanding- Control Group vs Intervention Group

A significantly higher percentage of the Intervention Group (70.0%) than Control Group (51.3%) enjoyed studying Organic Chemistry ($\chi^2(3) = 8.853$, $p = 0.012$). More of the Intervention Group than the Control Group found Organic Chemistry in the Leaving Certificate Chemistry Course easier to learn (49.0% vs 37.6%) and one of the most interesting areas of the Course (66.0% vs 51.3%).

Pupils in the Intervention Group were more confident about attempting an Organic Chemistry question in their Leaving Certificate examination and these pupils also performed better than the Control Group on a past examination question included in the Test for Understanding. This provides evidence that the *Organic Chemistry in Action!* programme was effective in preparing the pupils for the final examination as well as improving attitudes, interest and understanding.

Conclusion

The results indicate that this inquiry-based approach, grounded on ideas from Chemistry Education Research, which also aimed to develop cognitive skills and to relate Chemistry to real contexts, was successful in addressing, in part, some of the difficulties in teaching and learning Organic Chemistry at Second-Level. These teaching approaches are also applicable to introductory Third-Level Organic Chemistry.

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