

## [P24] Retaining weaker science students: a pilot project in Chemistry at the University of Limerick

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**Keywords:** chemistry education, retention, undergraduate students, weak students, chemical concepts

### Abstract

Higher Education in Ireland is seeing a new wave of students entering it. With this new influx of students comes a new set of issues and standards. This study sets out to examine the changing standards of incoming third level students today, and to also identify and unravel key problem areas for these students. *'Nevertheless, in order to maintain the present flow of students into higher education, the needs of this group must be urgently addressed.'* (Evans and Lewis, 1998)

This new diversity in third level is evident in science courses at the University of Limerick, particularly in undergraduate Chemistry modules. The Chemistry module that was examined typically has a failure rate of 30-40% at the first sitting. It is taken by students from five different degree courses (A-E). Students who fail this module are usually those in 'course A' and 'course B', and they are significantly weaker on entry than those in courses C, D and E.

In order to remedy this problem and thus improve the retention of the weaker students, we designed a pilot intervention programme for these two groups of students in the first semester of the 2008-9 academic year. This intervention was a 9 week programme covering basic chemistry. A pre- and post- diagnostic test of chemical concepts and misconceptions was designed and administered in the first and last session, together with an attitude/confidence test. The pre-test results were then used to design the course.

Initial results based on this intervention show, on average, a positive trend in both conceptual understanding and confidence levels. The performance of these two groups will also be evaluated in the regular course tests and the final examination, compared to the equivalent groups in the previous academic year, 2007-8.

### Introduction

In recent years there has been an exponential increase in the numbers of students in third level education. This is due to the Irish government's expansion policy on education. The last ten years has seen a massive increase in the numbers entering higher education in Ireland, so much so that in the year 2007 50-55% of 17-18 year olds entered higher education, with the goal being to reach 72% by the year 2020. (Higher Education Authority, 2008)

These larger numbers are largely viewed as a sign of growth and improvement in the education system, but they do lead to the problem of a very diverse group of students in higher education. It is important, with groups of wide ability that we ensure the weaker students do not get lost or left behind (Higher Education Authority, 2008)

The Higher Education Authority of Ireland (HEA) study on completion (Morgan *et al*, 2000) noted that while Irish students tend to have better 3<sup>rd</sup>. level completion rates than their European counterparts; the same subject areas across Europe have higher non-completion rates than others, such as Science. Science courses, in Ireland, at third level have significantly lower rates of non-completion (22.2%) in comparison to other courses such as Law (7.1%) (Flanagan and Moran, 2004)

A Submission to the OECD Review Team on the Irish Higher Education System in Irish Universities noted that '*The universities identified retention, completion and student withdrawal as important issues to be addressed and they have received increasing attention within the Irish university sector, particularly over the last 3 years.*' (Moore, 2004)

Studies evaluating initiatives to improve retention rates at third level noted that there was a need for learning-support programmes for students who were "weak" in critical areas such as Science and Maths. (Flanagan and Moran, 2004)

## Rationale

### Background to the Irish Third Level Entrance System:

In the first two years of study of Science in the University of Limerick there are widely diverse classes, due to differing entry qualifications required from students. Entry into Irish third level institutions is based the points accrued from six subjects taken at Leaving Certificate level, with an A1 grade at Leaving Certificate level earning 100 points and a D3 grade earning 45 points (on higher level papers). A maximum of 600 points can be earned through this system. These points for each third level course are determined each year based upon the number of course places and the student demand for them. Leaving Certificate examination results, third level applications and offers of course places from third level institutions are all processed through the Central Applications Office (CAO).

The number of points that one needs to be accepted into a course does not reflect the level of difficulty of the course, just its popularity. This leads to many Science courses having low entry points and consequently high dropout rates. For entry into third level Science courses most students usually have one Science subject on entry, but this may not be a subject that is relevant to the course that they are about to undertake. The numbers taking Science Subjects in previous years can be seen in table 1, with the vast majority of students who take science taking Biology, many students are under equipped to deal with a third level Chemistry course. (Childs, 2008) (Chief Examiners Report, 2008)

**Table 1:** Changes in the LC cohort and science subjects 2007-2009

| Subject   | 2007  | 2008  | 2009  |
|-----------|-------|-------|-------|
| Physics   | 14.5% | 13.6% | 12.8% |
| Chemistry | 13.8% | 13.6% | 13.7% |
| Biology   | 51.6% | 51.0% | 51.8% |

Those who have not done Science, in particular Chemistry, at Leaving Certificate level are often left behind, as they do not have an adequate grounding in the Science subjects. Sometimes, even those students who have done Chemistry at Leaving Certificate level are also weak with the 2008 Forfás Annual Competitiveness Report noting that of 21 countries surveyed, only three countries allocated less time to teaching science than Ireland. (National Competitiveness Council 2008)

### Motivation for the Study

Courses vary in the overall quality of the students, with some courses needing higher entry points and thus attracting the more highly qualified student and others have lower levels of points, yet are still difficult courses.

The 2<sup>nd</sup> Year Chemistry module that we examined has a failure rate of 30-40% at the first sitting. It is taken by students from five different degree courses (A-E).

The two courses 'A' and 'B' accounted for 95% of failures in the year 2007. One reason for this is that the cut off points for courses 'A' and 'B' are lower than those of the other courses taking the module. Another reason may be that there are a large percentage of mature students in both of these groups and both of these groups have completed little if any Chemistry at senior cycle. The aim of this intervention project is to try to help a group of students, identified as weak, to cope with introductory Chemistry courses. The following research questions have guided this project:

- Can diagnostic concept tests identifying students' prior chemical knowledge and misconceptions, be used to design successfully an intervention programme?
- How students' attitudes and confidence in the area of Chemistry affect their relationship to performance?
- Does this targeted intervention have an effect on the students' overall performance pre- and post-concept tests?
- Does attendance at the intervention programme made a difference in students' overall performance on the course?
- To what degree does student attendance at both the intervention sessions and lectures affect student performance?

## Methodology

A pilot intervention programme was designed for these two groups (course 'A' and course 'B') of students in the first semester of the 2008-9 academic year. This intervention was a 9 week programme of tutorials covering basic chemistry concepts. The intervention tutorials were an optional programme offered to the students and they did not have to attend. The limitation of this was that we were only able to measure the performance of students who attended most sessions and those who took both the pre- and post-test.

A pre- and post- diagnostic test of Chemical concepts and misconceptions was designed and administered in the first and last session. Questions for this test were taken from chemical concept inventories. (National Institute for Science Education 2008) (Journal of Chemical Education 2008). See figure 1 below, for a sample chemical concept question.

A sample question from both the pre and post diagnostic tests is shown in figure 1. The test also included an instrument measuring student attitudes and confidence towards science. The attitude tests were designed using the Likert scale. The pre- diagnostic concept tests were used to design the intervention programme in order to meet the students' specific needs. The students were taken in small class groups, rather than the larger lecture type style of class.

**Figure 1:** Concept test sample question on both pre- and post-tests

The circle on the left shows a magnified view of a very small portion of liquid water in a closed container.

Key  
 ○ Water  
 ○ Oxygen  
 ● Hydrogen

Liquid Water      Evaporated Water

What would the magnified view show after the water evaporates?

(a)      (b)      (c)      (d)      (e)

A unique feature of this intervention programme was to use the diagnostic tool to identify students' chemical misconceptions and to then use this to design the intervention programme to combat these misconceptions.

## Results

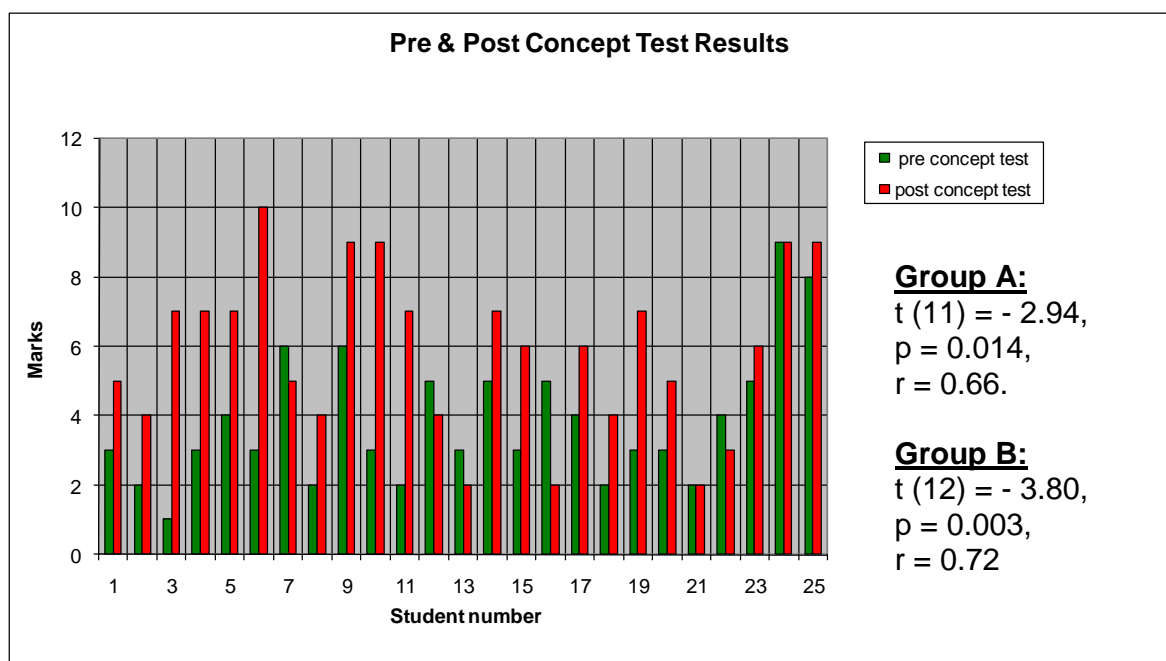
The results from this study have been positive. Students were given a pre-confidence/attitude test and a post-confidence/attitude test. Student's confidence to understand key concepts of chemistry improved in both groups, group 'A' had an improvement in confidence levels. They went from 50%,

of respondents choosing average and high, to 73% choosing those two options. Group 'B' had their confidence levels go from 50%, choosing average, to 56% choosing average and high. However, overall improvement in confidence levels in both groups was not significant. I.e. group 'A'  $p = 0.277$  and group 'B'  $p = 0.322$ .

There was a significant difference between pre- and post- concept test in a positive direction (completed after students have undergone the 9 week intervention programme). See figure 2. On average participants in Group 'A' experienced significantly higher results in the post-concept test, after the intervention programme ( $M = 39.08$ ,  $SE = 4.62$ ) than in the pre-concept test ( $M = 29.73$ ,  $SE = 4.17$ ,  $t(11) = -2.94$ ,  $p = 0.014$ ,  $r = 0.66$ )

Participants in Group 'B' also experienced significantly higher results in the post-concept test, after the intervention programme ( $M = 41.28$ ,  $SE = 4.49$ ) than in the pre-concept test ( $M = 22.05$ ,  $SE = 2.86$ ,  $t(12) = -3.80$ ,  $p = 0.003$ ,  $r = 0.72$ )

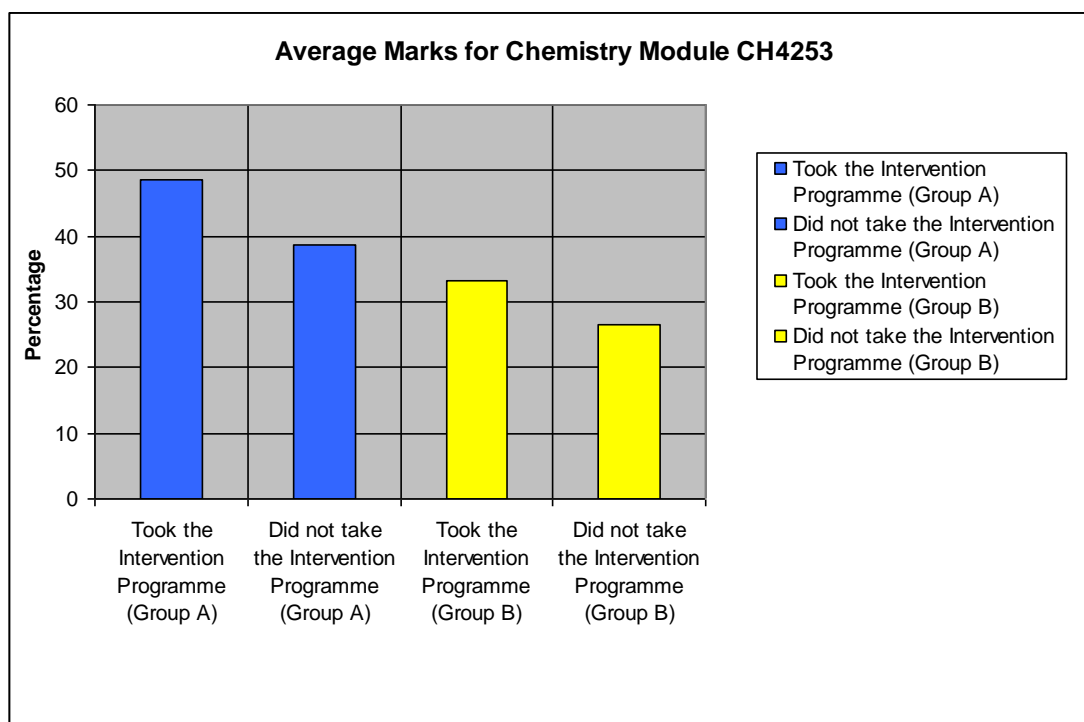
**Figure 2:** Comparison of Pre- and Post-test results for groups 'A' and 'B'



However, it was expected that students' would improve in the pre- and post- concept test. In order to examine whether the intervention programme had a more lasting effect, it was decided to examine students' results in the Chemistry module that was running alongside the intervention programme and in students' Chemistry module in the second semester.

Students in groups 'A' and 'B' take two chemistry modules in their second year. It was decided to examine the continued performance of students in group 'A' and group 'B' in these two modules, in order to determine if the intervention programme had any continued effect.

**Figure 3: Comparison of module CH4253 results for students who took intervention course vs. students who did not take the intervention course.**

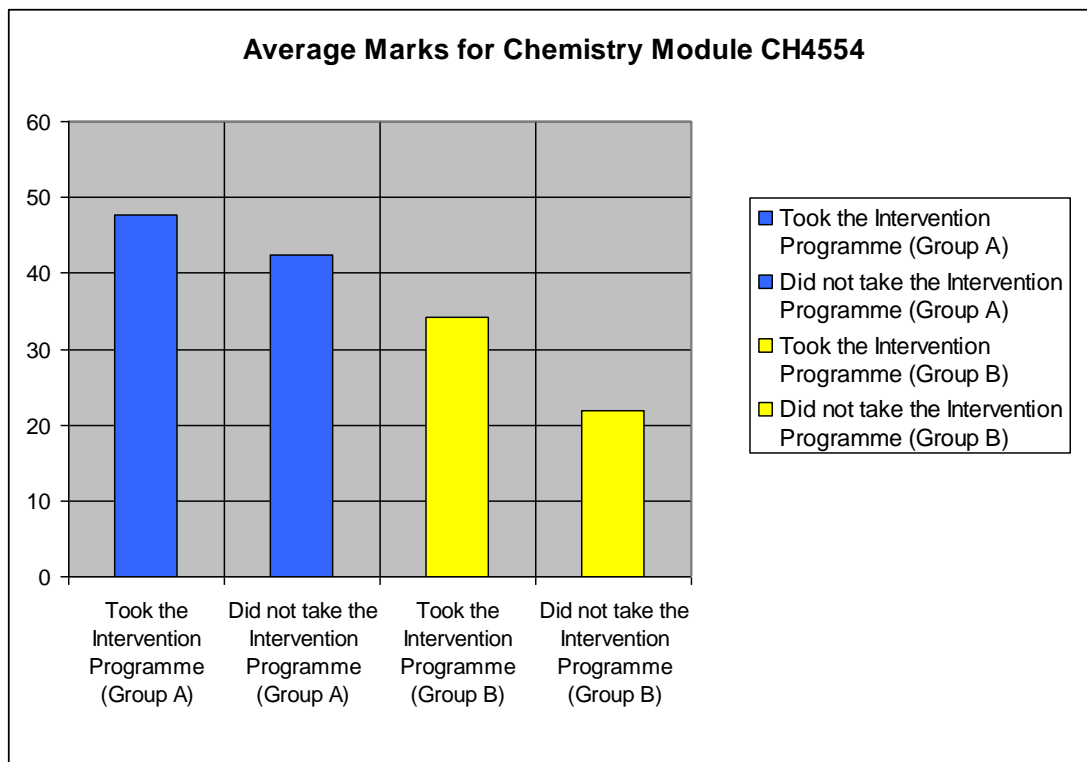


On average, in module CH4253, students in both groups that took part in the intervention programme did better than their peers. See figure 3.

In group 'A' participants in the intervention programme experienced slightly higher grades ( $M = 47.63$ ,  $SE = 3.38$ ) than those who did not take part in the intervention programme ( $M = 40.21$ ,  $SE = 3.22$ ). This difference was not significant  $t(29) = 1.53$ ,  $p = 0.138$ ; however it did represent a small to medium size effect  $r = 0.27$ .

Participants of the intervention programme in group 'B' experienced better grades ( $M = 34.09$ ,  $SE = 2.51$ ) than those in the group who did not take part in the intervention programme ( $M = 21.84$ ,  $SE = 3.47$ ). This difference was considered highly significant  $t(25) = 2.82$ ,  $p = 0.009$ ; there was also a medium -large size effect  $r = 0.49$ .

**Figure 4: Comparison of module CH4554 results for students who took intervention course vs. students who did not take the intervention course**



In the chemistry module CH4554 students who took part in the intervention programme were also seen to have better grades than those who did not take part in the programme. See figure Students in group 'A' who participated in the intervention programme had higher grades ( $M = 47.64$ ,  $SE = 2.29$ ) than those who did not participate in the intervention programme ( $M = 38.35$ ,  $SE = 5.79$ ). This difference was not significant  $t(23) = 1.50$ ,  $p = 0.155$ ; however it did represent a medium size effect  $r = 0.3$ .

Those in group 'B' who took part in the intervention programme had better grades ( $M = 33.29$ ,  $SE = 2.17$ ) than those who did not take part in the intervention programme ( $M = 26.45$ ,  $SE = 1.40$ ). This difference was considered to be significant,  $t(22) = 2.64$ ,  $p = 0.016$ . A medium -large size effect was also noticed  $r = 0.49$ .

### Conclusions and Implications

The results of this intervention programme are positive. The examination results of students who undertook this programme are better than those in previous years. However, this was an optional programme and while the results are encouraging, poor attendance in both the main module and in the intervention programme does affect the results. Many students who attended some of the nine week programme could not be assessed as they did not attend both pre- and post-test sessions. Poor attendance, both in the intervention programme and in the main module, can be linked with a lack of confidence. This programme successfully improved, not only chemical understanding, but also students' attitudes and confidence. The intervention programme was offered to students in the second year of study. We intend to run a similar intervention programme for the same groups of students in their first year of study, in order to equip them from the beginning of their course with the basic chemical understanding that they need.

Further study needs to take place in order to explore whether variables such as gender, points obtained in the Leaving Certificate, course attendance, previous study of Chemistry or Maths and over all college semester results have any effect on the results. In the next academic year it is planned to bring the programme back into students first year of university in order to target their misconceptions and chemical difficulties earlier. The programme will also be extended over a longer time frame.

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