



FINAL REPORT FOR A 1998 NATIONAL TEACHING DEVELOPMENT GRANT (INDIVIDUAL)

IDENTIFICATION

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Project Title

CoChem - An Innovative Approach to Interdisciplinary Advanced Chemistry Teaching

10 Key words or phrases that describe the project

Innovative modular laboratory program; hands-on experience in exciting new scientific technologies - solid phase combinatorial synthesis, ELISA biological testing and computer-aided molecular modeling; links chemistry and biology; for senior undergraduate chemistry students; investigative-discovery based; encourages independent learning, problem solving and analytical thinking skills; diversified nature extends practical skills; promotes interdisciplinary outlook; fun and real-life approach stimulates a greater interest in learning; prepares students for scientific careers.

Executive Summary

CoChem is a fun and innovative laboratory program for senior undergraduate chemistry students that contains exciting new technologies that brings together chemistry and biology. It provides hands-on experience for students in combinatorial chemistry, ELISA biological testing and computer-aided molecular modelling through a series of interlinking modules:

Module 1 - Microscale simultaneous generation of peptides related to the binding region (epitope) of the influenza protein hemagglutinin HA1 using solid phase combinatorial synthesis;

Module 2 - Epitope mapping and determination of the features critical for binding of the epitope to a monoclonal antibody using an Enzyme Linked ImmunoSorbant Assay (ELISA);

Module 3 - Computer-aided molecular modelling to examine the nature of the epitope-antibody binding at a molecular level.

By linking the combinatorial chemistry, biological testing and molecular modelling technologies, CoChem gives students a unique opportunity to develop up-to-date skills and appreciate the interdisciplinary nature of scientific work.

The incentive for the development of CoChem was the recognition that Australian universities teach chemistry with a narrow disciplinary focus, despite graduates being employed in areas where an interdisciplinary outlook is essential. This has left graduates and employers to bridge the gap between university teaching and job requirements. CoChem addresses this problem by providing real-life simulated learning that promotes an increased understanding and awareness of the interaction between chemistry and biology.

To assess the educational effectiveness and ease of use of CoChem, trials of the laboratory program have been conducted with undergraduate chemistry students at the University of Wollongong. The results of the trials were very positive. The modules were user friendly and sufficiently tolerant of the range of student capabilities to ensure that the vast majority of students achieved all the desired outcomes. The investigative, discovery-based approach of the program encouraged independent learning, problem solving and analytical thinking skills, while the diversified nature of the program, particularly with its exposure of new technologies, extended the practical skills of the students and stimulated a greater interest and more in depth understanding in chemistry and biology. In addition, the students found the program to be fun and particularly enjoyed the interlinking nature of the modules.

CoChem has been successfully incorporated into the third year curriculum of our Bachelor of Medicinal Chemistry Degree at the University of Wollongong. It is also being developed as a kit, containing the reagents, materials and instructional information necessary for carrying out the laboratory program, and will be available for distribution to other institutions in 2000. The CoChem laboratory kit will provide a useful adjunct to senior chemistry courses, increasing student understanding, knowledge and practical skills in the interrelated fields of chemistry and biology and promoting an interdisciplinary outlook in chemistry, thereby better preparing students for their scientific careers.

Teaching Innovation and Implementation

As a result of financial assistance from the CUTSD committee, the University of Wollongong, in collaboration with Chiron Technologies, has successfully developed CoChem - a fun and innovative modular laboratory program for senior undergraduate chemistry students that combines exciting new technologies at the chemistry/biology interface, *i.e.* combinatorial chemistry, ELISA biological testing and computer-aided molecular modelling.

Justification and Educational Rationale

In 1993, the Australian Research Council, in "Chemistry: a Vision for Australia",¹ strongly recommended that "...chemistry undergraduates need to be trained in the kind of environment which they would meet in their graduate employment". Despite this directive, in Australian Universities chemistry is taught with a narrow disciplinary perspective even though the majority of chemistry graduates are employed in industries, research institutes and government bodies that have an interdisciplinary culture. This has left graduates and employers to bridge the gap between university teaching and job requirements. This is a significant issue, with a number of companies, including our commercial partner in this project, Chiron Technologies, echoing the Australian Research Council sentiment, specifically stating that Australian chemistry graduates should have more developed interdisciplinary skills. The laboratory program CoChem, which enhances student understanding, knowledge and practical skills in the interrelated fields of chemistry and biology and nurtures an interdisciplinary outlook in chemistry, is therefore timely.

Target student group

CoChem has been integrated into our third year medicinal chemistry subject, CHEM330, which is a core subject of the Bachelor of Medicinal Chemistry Degree. This is a specialist subject and typically contains 14 to 20 students. There is, however, considerable potential for CoChem to be of benefit to a much greater number of students. A number of institutions in Australia and overseas have started to introduce medicinal chemistry subjects into their curriculum and CoChem would be an excellent laboratory program for these. CoChem is also an ideal laboratory program for senior undergraduate organic and biological chemistry subjects and due to its interdisciplinary nature, it would be a valuable addition to subjects undertaken by pharmacology and biotechnology majors. A number of institutions in Australia and overseas have already expressed interest in CoChem following presentation of our laboratory program at a national conference.

CoChem has only just been introduced into our third year chemistry class, so the benefit from the project outcomes each year cannot be fully assessed as yet. Trial runs of the laboratory program, however, have been undertaken and evaluated (see below). These show that CoChem increases student understanding, knowledge and practical skills in the interrelated fields of chemistry and biology and promotes an interdisciplinary outlook in chemistry. It should therefore prepare graduates more fully for their scientific careers

Technical soundness

All the modular components of CoChem have been found to be technically sound, with the materials and reagents used for the solid phase peptide synthesis (Module 1) and the ELISA biological testing (Module 2) performing to specification, and software used for the molecular modelling component (Module 3) being robust. The technical soundness is exemplified in trials with students of differing backgrounds. These trials have shown that the laboratory program is sufficiently tolerant of the range of student capabilities to ensure that the vast majority of students achieve the desired experimental outcomes. The modules were also found to give highly reproducible results when repeatedly examined in the developmental phase by technical staff.

Administrative Convenience and Organisational Acceptance

CoChem has been very easy to incorporate into our third year medicinal chemistry structure. The materials needed for running of the combinatorial chemistry and the ELISA components of the program have been supplied through our commercial partner, Chiron Technologies, and the University of Wollongong is equipped with the necessary facilities to successfully conduct all of the modules. Furthermore, for setting up and running of the program, no more technical assistance was required than that typically available in a chemistry teaching laboratory. As well as the appropriate technical assistance and infrastructure, complementary lectures covering combinatorial synthesis, computer-aided molecular modelling and antibodies (including use of ELISA) have already been fully developed for this course.

Trial runs have shown that CoChem successfully achieves the expected experimental and learning outcomes desired, however, as it has only just been incorporated into the third year curriculum further evaluations of assessment and feedback over a longer time frame are necessary to fully assess how successful the project outcomes have been embedded.

Evaluation

CoChem has been evaluated by both formative and summative methods. After initial development, the program was trialed by a group of volunteer undergraduate students (10 third year medicinal chemistry students). The students were given no prior information on the laboratory and asked simply to follow the student manual developed. This is more severe than the recommended procedure for the running of the laboratory program where students are provided with tutorial and background information before commencing the program. This approach was purposefully taken to assess the full degree of difficulty of the program and to allow reshaping of the manual to make it student-friendly. Subsequent to the trial students were asked to critically evaluate the educational effectiveness, success rate and ease of use of the laboratory program. The trial clearly demonstrated that the program promoted an interdisciplinary outlook and increased understanding, knowledge and practical skills in chemistry and biology. Furthermore, the students provided valuable feedback that was used to further modify the modules and the student manual. Following modifications, a subsequent trial was run with 20 students of a more varying background, including medicinal chemistry students, students without prior biological chemistry experience and foreign speaking students. This was more formally assessed with questionnaires and again was found to be extremely successful in achieving the objectives of the program.

The evaluation is an ongoing process. The students who have just commenced the laboratory program in the third year medicinal chemistry subject will be evaluated in a similar manner to the above students by examining perceived learning, understanding and enjoyment via questionnaires. In addition assessment of their practical reports and lecture materials related to the modules will form the basis of a summative assessment. Once these evaluations are completed and analysed professionally the results will be used to modify the modules further and complete the instructional material. We also wish to evaluate the program externally before it is available for distribution. The Victorian College of Pharmacy has kindly volunteered to participate in this trial. This will be particularly valuable in assessing the ease of integration of the laboratory program into other institutions.

Implementation of CoChem into other institutions

The areas that CoChem covers are technologies at the forefront of chemistry and biology. Most educational institutions have recognised this and have introduced these technologies into the lecture components of their subjects. In addition, many institutions now have access to the molecular modelling and ELISA facilities needed for implementation of CoChem. Therefore, other teaching institutions will find CoChem an easily integrated and very useful adjunct to their courses. It must be noted that given the new technologies being used for CoChem, some of the items required, such as the solid phase peptide pins, antibodies and pipettors, are

relatively expensive, so cost of the kit will not be low. However, most of the materials and equipment in the kit are reusable and many of the reagents are needed in only very small quantities due to the microscale nature of the program. Given the cost, it would be ideal to use CoChem for groups of 15-20 students at any one time. It would also be recommended that students have studied some immunology (covering antibody-antigens) and protein chemistry prior to commencing the laboratory program. However, students that took part in the trials who had no background in these areas still achieved good experimental results and obtained a good grasp of the concepts covered.

Future Direction

CoChem will be continually evaluated at the University of Wollongong and it will also be evaluated externally to ensure that all learning objectives are fully met and that the laboratory program is optimised, especially the instructional package, for easy implementation at other institutions. Information on CoChem will also be widely disseminated through the web, via articles in *Chemistry in Australia*, which is a publication that reaches many chemists within Australia and New Zealand, and in the *Journal of Chemical Education*, and via conferences (e.g. the Royal Australian Chemical Institute National Convention in February 2000). The University of Wollongong's educational funding schemes such as "Challenge Grants" will be investigated to aid the marketing and distribution of the kits in 2000. This distribution will be carried out jointly by the University of Wollongong and Chiron Technologies.

References

1. "Chemistry: a Vision for Australia", Australian Government Publishing Service, Canberra, 1993.

Dissemination

Conference Presentation (oral)

“An Innovative Approach to Interdisciplinary Medicinal Chemistry Teaching: Joanne Jamie, Katherine Moerman, Geoff Wickham, Paul Keller, Stuart Rodda and John Bremner. 14th National Conference, RACI Division of Medicinal and Agricultural Chemistry, University of Wollongong, 22-25 November, 1998.

Conference Presentation (poster)

“Linking Chemistry and Biology in a Fun Undergraduate Practical? I’d Like To See That!!!” Katherine Moerman, Joanne Jamie, Geoff Wickham, Paul Keller, Stuart Rodda and John Bremner. 14th National Conference, RACI Division of Medicinal and Agricultural Chemistry, University of Wollongong, 22-25 November, 1998.

*Won best poster prize at the conference.

Further dissemination of the material is planned at the end of the year, following evaluation of the current third year students and the trial at the Victorian College of Pharmacy. The results of these and the earlier trials will form the basis of a paper that will be submitted to the *Journal of Chemical Education*, and the work will also be presented at the Royal Australian Chemical Institute National Convention in February, an ideal vehicle to advertise the program as it will have delegates from Australia and overseas. The final kit will be advertised in *Chemistry in Australia*, an Royal Australian Chemical Institute production that reaches Australian and New Zealand institutions, via the web and Uniserve Australia and via chemical education groups on email.

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The co-investigators on this project:

From Chiron Technologies: Dr Geoff Wickham (came up with the original concept for the project) and Dr Joe Maeji.

From the University of Wollongong: Dr Paul Keller (provided expert advice for the computer-aided molecular modelling module), Mr Robert Corderoy (educational consultant) and Prof. John Bremner.

The Research /Technical Assistants at the University of Wollongong:

Katherine Moerman - research assistant throughout most of the project. Katherine did the majority of the hands-on development of the project and made it the success that it is.

Chris Dixon - technical assistant for the third year medicinal chemistry course. Chris has provided valuable technical assistance for the running of the program.

Krystal Evans - research/administrative assistant. Krystal has provided research and administrative help throughout the latter stages of the project.

From Chiron Technologies:

Stuart Rodda - Stuart trained Katherine in the techniques needed for the solid phase peptide synthesis and ELISA biological testing and consistently offered advice.