

## BestChoice: Interactive Web-Based Learning

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*BestChoice* is an open-access interactive web site ([www.BestChoice.net.nz](http://www.BestChoice.net.nz)) that was developed initially to support learning in large first-year Chemistry classes at Auckland University. More recently, *BestChoice* has been expanded to provide learning opportunities for high school students in NZ and the UK. The model underpinning *BestChoice* learning activities is simulation of the interchange of a student with an experienced teacher. Thus, student responses on *BestChoice* question pages generate instant assessment and feedback. *BestChoice* is innovative in its emphasis on teaching both concepts and problem-solving strategies by guiding students in ways that promote their understanding. The design of activities, promotion of their usage, and evaluation of their effectiveness is described below along with outcomes relating to these three strands of the project.

### Background to the Design of *BestChoice* Activities

#### *Facilitating both teaching and learning using web-based activities*

Teaching Chemistry to large first-year university classes is essentially the transmission of information to students who adopt a passive role. However, for quality learning to occur, the student must assume an active role and engage with the content through problem-solving. Often the subject expert is not readily accessible to offer guidance to the student during the learning process. This may cause

- uncertain learners to become discouraged and conclude that chemistry is *too hard*;
- confident learners to solve problems algorithmically without developing understanding.

It was envisaged that *BestChoice* activities could support the learning process by acting as a bridge between *hearing about it in lectures* and *doing it yourself*. Thus the activities would both connect with and be complementary to traditional learning resources, particularly in that usage of activities could be tracked in order to detect how better to support learning.

#### *Connecting web-based learning activities and other study resources*

Traditionally, students study using print materials. They solve problems using pen and paper. Many students prefer to have model answers readily accessible.

If *BestChoice* activities are to be valued as learning tools, their relationship to traditional study tools must be obvious. Authors can establish this connection by:

- constructing visually appealing pages using conventional symbolism in the display of mathematical and chemical concepts;
- developing activities that help students learn how to solve problems that appear on written assessments;
- giving users ready access to correct answers and to background material required.

### *Overcoming some of the limitations of fostering learning over the web*

*Reading from the screen is more difficult than reading from a printed page.*

Information can be presented in a way that prevents cognitive overload with an emphasis on requiring users to answer questions. Content can be exposed in small quantities in the feedback generated by the user's response.

*Waiting for downloads or for the computer to respond is frustrating.*

A text-based web application that used graphics and animations only where necessary allows it to be used on slow internet connections.

*Common web browser answer-input devices (text-boxes, dropdown lists) do not support subscripts and superscripts.*

This limitation can be overcome by developing an authoring system that includes answer input devices with support for both images and formatted text.

### *The teaching model*

Web-based activities that simulate a person-to-person tutorial with an experienced, patient teacher would complement existing learning resources. Implementation of this model would involve developing activities that mix explanation of concepts with questions to probe the student's level of understanding.

### Implementation of *BestChoice*

#### *BestChoice for the web - 2002*

The web site went live in 2002, with a total of 1900 pages in 60 modules available. Some 90% of the pages were question pages; thus, as intended, the emphasis was on users entering responses that generate feedback.

In *BestChoice* activities concepts are presented in *Review Pages*. Typically these are brief and highlight only major principles. Most modules begin with such a page. The concepts are then developed further through:

- questions on pages that follow each Review Page;
- feedback displayed when users answer questions on *Question Pages*.

The feedback relates either to the previous review page (by reiterating principles) or presages the next review page by applying and extending the principles. Thus, during completion of a module, learning is monitored with the constant feedback and guidance provided by the system. Some students struggle to understand what the question requires or may not be able to enter the correct answer. Such users have the option for the system to show them the correct answer so that they can overcome this barrier and move on to complete the problem.

The use of *BestChoice* was recommended to students in two first-year courses at Auckland University in 2002. An end-of-semester survey in one of the courses endorsed the approach taken in the modules. The survey asked *What feature of BestChoice did you like best?* The two most common responses were *combination of questions and review pages* and *feedback*.

While we had put in place the structure described above, and had some validation of the approach to supporting learning, *BestChoice* 2002 was limited to one answer per question page. This meant that the stepwise solution of a multistep problem extended over several pages. Furthermore, an absence in control over positioning of the answer fields and the associated feedback severely hindered authoring.

### **BestChoice for the web 2003-2008**

Both the content and system of *BestChoice* have been upgraded and expanded on a continual basis over the last five years. Currently there are more than 200 modules with 8000 possibilities for interaction that result in instructive feedback. An extensive web-based authoring system has been developed to enable authors to construct question pages with:

- any number of answer fields;
- answer fields and their associated feedback incorporated in the text of the page;
- a variety of types of answer fields;
- correct answers to one part of a page triggering the appearance of a second part.

### **Promoting Usage of *BestChoice* as Part of Course Materials**

#### ***Connecting the BestChoice activities with the student's course of study***

Teachers choose course resources to help students study. In order for *BestChoice* learning activities to be accepted as a course resource, customised courses have been constructed for target groups. In these courses the modules are grouped, and the groups are placed in a sequence that corresponds to the course outline. The number of target groups has grown in the last five years to include for 2008 students in Chemistry classes: at Auckland University (seven courses); in NZ high schools (NCEA Year 11-13, Scholarship and Olympiad courses); in the UK (AS/A2 levels courses for the four major exam boards); at Canterbury and Victoria Universities (one course each). Access is not limited to users in these target groups as anyone may register. Thus, two generic courses, General and Organic Chemistry, are also available.

#### ***Use of BestChoice by chemistry students at Auckland University***

*BestChoice* was compulsory in two first-year courses at Auckland University in 2003; In 2008, modules are compulsory in six first-year courses. These courses range from foundation level to those compulsory for students trying to gain admission to Health Sciences programmes. In total, approximately 2000 users are involved.

Although one of the authors has had extensive experience teaching first-year chemistry, neither is currently lecturing in

any of the first-year chemistry courses. Therefore, the support of course coordinators and teachers is crucial to:

- introduce their class to *BestChoice* and provide details of registration;
- promote *BestChoice* activities as learning experiences;
- encourage students to use *BestChoice* to support their learning during the entire course

For 2008, modules will be used in all of the first-year courses as both assignments and pre-laboratory activities. In general, course coordinators began to use *BestChoice* modules for assignments or pre-laboratory study and then, based on a successful experience, have extended its use in their course to include both assignments and pre-labs. It has been noted for a variety of courses that, when the compulsory requirement is increased substantially, an increased percentage of students complete the compulsory modules. Furthermore, an increase in the use of non-compulsory activities also occurs.

The *BestChoice* pre-laboratory activities replaced written material that was marked by supervisors at the beginning of the laboratory session. Because the *BestChoice* pages are marked as they are completed, supervisors now have more time to help students with practical work at the beginning of the session. Course coordinators also believe that there is less blind copying and more opportunity for learning than before.

#### ***How do teachers monitor their students' BestChoice activity?***

*BestChoice* collects a variety of data for each user. These include demographic details (user-entered), registration date, number of logins, and a count of the pages on which answers have been entered, as well as the number of attempts required to get the correct answer, and the time interval over which the question was answered. These data are available to a teacher through the complementary application *BestChoice Reports*.

#### ***Use of BestChoice by high school students***

During the period 2003–06, NZ high school teachers were made aware of *BestChoice* both through an electronic newsletter circulated by a high school teacher and through a series of presentations at Teacher's Days held at the universities around the country. In 2007 *BestChoice* and *BestChoice Reports* featured in a flyer in the package of educational materials distributed by the RSC to all schools in the UK. For the NZ 2007 and the UK 2007-8 school years, teachers in these two localities were offered use of *BestChoice Reports* at no cost.

Most high school usage is voluntary. Students are often introduced to the programme by their teacher using a period in the school computer lab. Teachers who are *BestChoice Report* users may assign *BestChoice* modules for homework. However, this practice is not widespread as yet. The pupils of teachers who are *BestChoice Report* users are the more likely to become active users, but some 53% of 2007 *BestChoice* use in NZ high schools was by students who are not enrolled in a *BestChoice Reports* class.

## Evaluating *BestChoice* through usage data

### Usage of *BestChoice* has grown steadily

Table 1 shows that there has been a steady increase in user numbers during the last four years. NZ high school students began using the programme in 2004 and usage in 2007 more than doubled from 2006. Active users are from 250 different NZ schools. Use by UK high school students from September '07 also contributed to the large increase in the number of users in 2007.

Table 1. Number of *BestChoice* users

Login year	2004	2005	2006	2007
Users (>1 mark*)	5109	6410	7040	13868
Active Users (>80 marks)	3380	4112	4546	7996

\*Each answer in *BestChoice* is worth 1 mark.

### The importance of the connection to the user's course of study

The distribution of users and activity for 2007 (Table 2) shows that 99% of usage is by three of the target groups for whom specific courses have been created. Teachers in these target groups actively promote use of *BestChoice*, and some have made completion of some *BestChoice* modules compulsory. Most of the remaining 1% of active use is by students from Canterbury University where some staff encourage voluntary usage.

Table 2. Distribution of users and usage in 2007

Institution	Auckland University	High School		Other
		NZ	UK	
Users	3186	6940	3579	163
Active users	2842	3344	1732	78
Total marks/1000	2240	1480	530	42

## Evaluation of *BestChoice* using an on-line survey

### Establishing mechanisms for on-line evaluation of *BestChoice*

One of the most important aspects of the *BestChoice* project is the extent to which our users have informed its development. In order to encourage student users to indicate what they liked best and how things could be improved, the survey displayed in Fig. 1 was included on the last page of each module. Thus, users may enter comments and rate modules on a six-point scale. This has provided continuous user feedback.

The comments entered in the survey indicate the student perception of *BestChoice*.

The on-line survey has been a very rich source of student comment, most of which is pertinent to teaching and learning. Of the 5133 complimentary comments entered during 2003-2007, six unedited examples appear below:

Fig 1. End-of-module Survey

**User 1:** Wonderful! Sooooo helpful! Best feature is that you can read the theory, then do the quiz! (Nov 03).

**User 2:** This was fun and helped me understand much easier. I was not placed under pressure at all, because I was allowed to make mistakes. I really enjoyed this. (Mar 04).

**User 3:** This has made so much that I didn't understand much clearer. The little amounts of information followed by heaps of questions makes it really easy to absorb! (Aug 03).

**User 4:** Awesome. Extremely helpful on specifics and terminology. It's great to be able to back up school resources with another reliable website that revises and teaches in an easy to follow format. (Aug 07).

**User 5:** This site is AWESOME!!! I'm really glad there's something like this up and running to help students who are willing to study at home. it gives a break from just reading and doing examples from books and really helps!!! I'm sure my marks are going to improve!!!! THANKS!!! (Apr 03).

**User 6:** I learnt a lot, & it went smoothly, gradually getting harder & making me learn much more efficiently; it is very helpful thank you (May 03).

The comments made have been assigned to categories. Three of these (complimentary, suggestion and critical) are relevant to teaching and learning; 70% of comments have been assigned among these. Some 6% do not pertain to *BestChoice*, and 24% highlight typographical errors and bugs that have been fixed.

Table 3 shows the distribution among the categories relevant to teaching and learning. Many of these comments have multiple threads. Any comment that includes a compliment is assigned to *compliment*. Critical comments that include a suggestion are assigned to *suggestion*. The fact that substantial increase in the quantity of feedback has made little change to the distribution provides endorsement of the enhancements that have been made to both the system and its content during these three years.

Table 3. End-of-module survey response summary

Year	Total	Compliment	Suggestion	Criticism
2007	3357	64%	19%	17%
2006	1658	70%	17%	14%
2005	1173	68%	15%	17%

The *comment* data indicate that, in general, learners perceive *BestChoice* to be beneficial to them and help them learn. Many of the suggestions made by users have been implemented. Some of the problems identified could be rectified easily and, in contrast to print-based materials, the revision is available immediately.

The ratings (out of 6) indicate that most students find the modules helpful

Students indicate how helpful they have found a module by choosing one of the six radio buttons at the end of the module survey form. The range is from *not at all* (1) to *fantastic* (6). The average response rate to this part of the survey over all modules and all cohorts of users is 30%. As shown in Table 4, the radio buttons corresponding to 4, 5 and 6 ratings are much more commonly chosen than those corresponding to 1, 2 and 3 ratings. The most frequent choice in each year is *fantastic* (6).

Table 4. Survey ratings response summary

Year	Responses	Average out of 6	% positives (4,5,6)	% highest rating
2007	19756	4.62	81	32
2006	9680	4.74	84	35
2005	6866	4.64	82	32

## Outcomes in terms of the three strands of the *BestChoice* project

### Instructional design

The construction of web-based activities consistent with our model of a one-on-one tutorial was a major challenge that required development of our own authoring system. Once this was in place, translation of pen-and-paper exercises to *BestChoice* activities became feasible.

Our project activities generally add value to the pen-and-paper exercise. Figs. 2-4 show how this is done for the task shown below, *viz.*:

Reaction of Cu (metal) with  $\text{Ag}^+(\text{aq})$  results in precipitation of silver metal, Ag. Write the half equation for this reaction.

The view on loading the *BestChoice* page is shown in Fig. 2. If the correct choice for each of the options presented is chosen, feedback associated with these choices is revealed as well as the next part of the problem (Fig. 3). The third part is shown in Fig. 4. Any incorrect choices can be changed without leaving the page and interrupting the flow of problem-solving.

These screen shots show that users do not simply answer the question posed on pen and paper. A *BestChoice* page based on this question forces the student to analyse the system involved and use appropriate terminology in doing so. Thus, *BestChoice* exposes the strategy that a subject expert would use to answer the question. The pages are as much about the thinking behind arriving at the right answer as they are about the answer itself.

The guidance offered by *BestChoice* pages such as this one (Fig. 4) makes successful completion of the problem more accessible for more learners who, over time, should gain the skills to answer the questions without guidance. Consider the unedited comments:

**User 7:** The main thing I liked is that it gave me the opportunity to practice and learn from my mistakes (Mar 06).

**User 8:** liked this topic. Being able to see and work everything

Reaction of copper metal with  $\text{Ag}^+(\text{aq})$  results in precipitation of silver metal (Ag).  
Choose or enter answers below to complete the statements.  
You may have to press SUBMIT to get your answers marked.

In this reaction  $\text{Ag}^+$  is acting as an  electron acceptor or  electron donor or  oxidant or  reductant.

Fig. 2. *BestChoice* problem page view on loading

Reaction of copper metal with  $\text{Ag}^+(\text{aq})$  results in precipitation of silver metal (Ag).  
Choose or enter answers below to complete the statements.  
You may have to press SUBMIT to get your answers marked.

In this reaction  $\text{Ag}^+$  is acting as an  electron acceptor or  oxidant.  
When an atom accepts electrons, its oxidation number becomes more negative.  
Oxidants are also known as oxidizing agents.

Electrons are a  reactant or  product in the  $\text{Ag}^+(\text{aq})$  to  $\text{Ag}(\text{s})$  half equation for this reaction.

Fig. 3. *BestChoice* problem page view after making two correct choices

Reaction of copper metal with  $\text{Ag}^+(\text{aq})$  results in precipitation of silver metal (Ag).  
Choose or enter answers below to complete the statements.  
You may have to press SUBMIT to get your answers marked.

In this reaction  $\text{Ag}^+$  is acting as an  electron acceptor or  oxidant.  
When an atom accepts electrons, its oxidation number becomes more negative.  
Oxidants are also known as oxidizing agents.

Electrons are a  reactant or  product in the  $\text{Ag}^+(\text{aq})$  to  $\text{Ag}(\text{s})$  half equation for this reaction.

Complete the half equation.  
 $\text{Ag}^+(\text{aq}) + \square \text{e}^- \rightarrow \text{Ag}(\text{s})$

Fig. 4. *BestChoice* problem page view after making third choice

out myself really helped me understand this. Thanks (Mar 06).

**User 9:** Very helpful, especially the first 8 questions, very good!! They were hard, but they made me think a lot and I ended up getting most of them right (Aug 07).

*BestChoice* activities also provide capable learners with an enhanced learning experience as insights are revealed during problem-solving and appear in the form of feedback just as the user has entered the answer that they thought was correct. Thus:

**User 10:** Very good, now I understand alot more little things I would've never thought of asking (Mar 06).

**User 11:** this was useful because it made me think logically about the electron configurations rather than just having a bit of a guess (Oct 07)

It is a challenge to accommodate the variety of learning styles and academic backgrounds in any class irrespective of whether it is high school or university. Web-based activities like those in *BestChoice* can add to the suite of tools available to help meet this challenge. A written survey in some of the courses where *BestChoice* is compulsory asked students *Which feature of the course helps to you to learn?* The results (Table 5) show that many of the responses indicated more than one feature. Thus, the students regard *BestChoice* as an effective learning tool for use alongside other traditional tools. It is not, and was never intended to be, a replacement for these.

Table 5. Student in-class survey response summary

Cohort	Surveys/ Responses	Best-Choice	Labs	Lectures	Hand-outs
BSc 1	100/62	47	21	5	
BSc 2	170/111	37	25	20	44
Pre-uni	80/63	25	NA	28	13

**Evaluation**

Unlike the most other learning tools, use of *BestChoice* by students automatically generates data that can provide information on how to support learning more effectively and efficiently. We have shown that, through these data, users can inform the design of systems to support their learning. The extent and quality of feedback entered by users has been overwhelming.

*User 12:* BC helps me understand chemistry in a way that is both faster and more convenient than tedious text book exercises - almost like having a personal tutor watching over my shoulder. Thank you and keep up the good work! (Apr 06).

*User 13:* *BestChoice* is simply the best learning technique i ever came across. It walks me through the important steps to follow in order to solve a question and makes the theory more simpler (Mar 06).

*User 14:* really helpful, different way of looking at things than portrayed in the lecture, gave depth of understanding (May 07).

The most frequent suggestion entered in the survey is *more questions*. New question pages are being added on a continual basis. An important aspect of the writing of these is that new ways to present content interactively are being explored on a continual basis.

The foregoing discussion includes a broad analysis of data pertinent to student perception and usage. We have also considered student response data for individual modules and questions in order to identify areas found difficult. This process has informed the on-going updating of existing learning activities and authoring of new ones.

The data collection process makes it easy to see where students are going wrong, the authoring system makes it possible to create activities that address the student difficulties identified, and usage of these activities in turn generates data that provide evidence as to the success or failure of the *improvements*. This evidence-based methodology contrasts

markedly with the *working blind* approach that one is forced to adopt when revising or creating most teaching resources.

The world-wide web has enabled communication and dissemination of ideas in ways that were beyond belief even 10 years ago. There is also a lot of talk about using the web to foster learning. However the extent to which most web-based content has moved beyond passive learning is minimal. *BestChoice* stands out from the rest both with respect to the emphasis on active learning, where student responses result in display of appropriate feedback, and the evidence-driven approach used to create and up-date content.

A web-based application like *BestChoice* could become an international resource informed by both educators and students world-wide. Our work for the UK-based RSC is a major step towards achieving this for high school students. The significant challenges at national level are to increase teacher participation in use of *BestChoice Reports* and to find ways and means of encouraging and supporting extensive use of *BestChoice* at other universities.

Both our experience in the journey to *BestChoice 2008*, and the substantial positive feedback from our users, lead us to believe that we have only just begun to exploit the potential of the web to deliver interactive learning. Therefore, extension and enhancement of *BestChoice* will continue. It is very exciting to be involved in the creation of a learning tool, the development of which is informed by the learners.

**Acknowledgement**

We acknowledge course coordinators, lecturing staff, and teachers who have recommended use of *BestChoice* to their students. The Chemistry Department and the Teaching Improvement Grants Committee of Auckland University have provided financial support throughout the project. The work with high school students has been made possible through support by the RSC in the UK (2006-2010) and in NZ by the Ministry of Education (2006-2008).

**Obituary: Ken Seal (1923-2007)**

Ken Seal, Hon. FNZIC and Past-President, died in Auckland on 29 October 2007, aged 84. He was a bright and enthusiastic member of the Auckland Branch for many years.

Ken was born in England. At primary school he won a scholarship to attend Kilburn Grammar in London. From there he was offered employment by GEC who agreed to pay his fees to attend Birkbeck College, University of London, which operated as a part-time university with courses and laboratory work on Saturdays and Sundays only. Ken graduated with BSc and MSc degrees in geology. At GEC he worked on a number of war-related scientific projects, which exempted him from military service when he reached conscription age later in the war.

He, and his wife Joy, migrated to NZ in 1952 where Ken took up employment with Amalgamated Brick & Pipe Company in Auckland. There, he was responsible for quality control and development work on their products, and this work was later extended to similar work for the later named company, Ceramco. Both companies were managed by the well-known Auckland entrepreneur, the late Sir Tom Clark.

In the early 1970s Ceramco was a shareholder of Geothermal

Energy NZ Ltd., set up to utilise NZs expertise in producing electricity from geothermal steam. Ken was one of its geochemists who later became a director of the company. A major project was to assist Indonesia as part of the largest NZ aid project of that time. Ken served as its project manager from 1971-1975 returning to Ceramco and Auckland in 1975. He continued his geothermal consulting work around the world throughout the 1980s until his retirement.

Ken was a significant contributor to NZIC. At meetings he was always liked for his questioning nature and great enthusiasm for chemistry. He read widely, painted, and had a life-long interest in scouting. For his efforts as a young messenger in the early years of WWII he was awarded the Silver Cross for Gallantry. During a bombing raid he had, under the guidance of a doctor working nearby - himself unable to undertake the procedure - amputated the arm of a woman trapped in a burning building. He was awarded the CBE for services to New Zealand in 1977.

Ken is survived by Joy and their children Lesley, Kingsley and Heather.

Ashley Wilson