Practice

Evaluation of student engagement with two learning supports in the teaching of 1st year undergraduate chemistry†

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Abstract: This paper attempts to draw together students' interaction with an organic chemistry module on Virtual Learning Environment (VLE) (*Moodle*), their interaction with another learning support (*Drop-in Science Clinic*), the approach they have adopted to their learning of chemistry and their performance in the terminal end of year chemistry examination. It discusses student trends of usage of the VLE and relates this to their examination success. Their performance in the organic section of the examination is compared to that of the physical chemistry section in which the students' did not have VLE support materials. Students' usage patterns for accessing resources on *Moodle* were analysed. Interesting patterns of first access are shown. In general, those who interacted with the resources on *Moodle* did better in their terminal examinations, showing that students who were conscientious in their studies did better in their examinations. [*Chem. Educ. Res. Pract*.**,** 2007, **8** (4), 390-402.]

Keywords: Introductory undergraduate chemistry, students' approaches to learning, learning supports, virtual learning environments (*VLE*), Drop-in-science-clinic (*DISC*)

Background

It is internationally recognised that the physical sciences are facing problems of student disengagement (Fensham, 2004). Fensham has discussed possible causes, such as a curricular focus on attainment of scientific knowledge without attention to motivational aspects of science. He has noted the importance of scientific literacy and technology in encouraging an interest in science. Computers have been prevalent for many years in the physical sciences in that they are used in instrumentation and in data analysis within undergraduate programmes, and students have become adept in their usage. In Ireland, higher education reform has proposed the development of new ICT pedagogy for the improvement of teaching within higher education (HEA, 2004). This reform has been stimulated by industry's call for a technically skilled workforce, and indeed, to address the needs of a changing society.

There is a plethora of ICT resources and products available for use within the physical sciences. These resources include online lecture notes and tutorials, interactive software programmes, Virtual Learning Environments (VLEs e.g. webCT, blackboard, Moodle) and simulations.

VLEs are in widespread use. In the UK, a *University Colleges and Information Systems Association* (UCISA) survey by Browne and Jenkins (2003) noted that 86% of their respondents are using a VLE in their institutes. Recommendations on the implementation and evaluation of VLE have been discussed (Bell et al., 2002, Boyle et al., 2003, Sharpe et al.,

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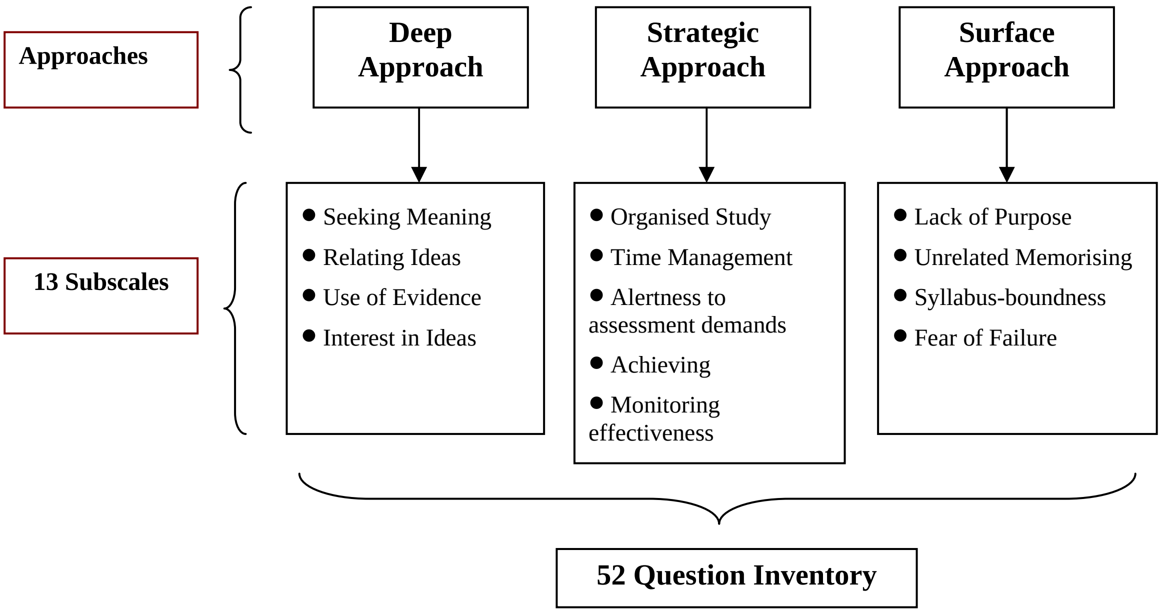
2006). While anecdotal evidence seems to suggest that students like access to lecture notes and tutorial questions through VLEs, there has been little evaluation on the effectiveness of these supports in teaching and learning. Indeed, Rogers (2004) noted that while there are gains in using learning technology, the claim that it can 'make the difference' to deeper learning requires much more research before further investment should be considered.

The VLE used in this study was *Moodle*. It is a web based Course Management System that allows the user to develop a VLE. It is open source software that can be freely downloaded from the web. There is an on-line Moodle community with over 200,000 registered users of the host site moodle.org. It is easily used and internationally accessible. It allows the educator to develop a course with multiple functions, including file hosting, quizzes, assignments, chats, discussion forums, glossaries and questionnaires. It is similar to the commercially produced VLE blackboard.com.

Another aspect that should be considered when looking at student engagement is the approach that students adopt to their learning. Approaches to learning examine how students relate and interact with a task and their intention in relation to a task; they are indicative of the quality of learning that takes place (Ramsden, 1992).

Ramsden distinguishes between learning for real understanding (i.e. adopting a *deep approach*) and imitation (i.e. adopting a *surface approach*). A deep approach refers to active engagement with a task in order to obtain meaning, i.e. when students intend to relate with a task in a manner that will allow them to understand the facts of a task in relation to the real world concepts (Marton and Saljo, 1992). A surface approach, on the other hand, refers to students obtaining information in a random pattern for short-term recall. A third approach to learning is known as the *strategic approach*. This is an approach "*in which the intention is to achieve the highest possible grades by using organised study methods and good time management*" (Entwhistle, 2000). The two most recognised inventories in the literature to measure student approaches to learning are those of Biggs (Study Process Questionnaire (Biggs, 1979)) and Entwistle (ASSIST- Approaches to Study Skills Inventory for Students (Entwhistle, 2000)). In this research, the ASSIST inventory was used.

Figure 1: ASSIST inventory, approaches to learning (Entwistle, 2000).



In the ASSIST inventory, approaches are broken down into 13 different subscales as shown in Figure 1. The deep approach is broken down into four subscales, namely, seeking meaning, relating ideas, use of evidence and interest in ideas. The strategic approach is broken into five subscales and the surface approach is split into four sub-scales. Each of the subscales is assessed by four statements on the inventory to which students have to respond. A 1-5 Likert-scale is used where 5 refers to agreement and 1 indicates disagreement with the statement. Thus in total there are 52 statements that students have to respond to, four of which corresponds to a subscale, which in turn combine to one of the three student approaches.

Student engagement may also be influenced by prior knowledge in the sense that a student may become demotivated due to lack of basic knowledge that can often be assumed in a lecture course. To tackle this issue, a *Drop-in Science Clinic* (*DISC*) was made available, where students could 'drop-in' at a time that suited them, to obtain help in any of the science subjects.

This study attempts to obtain answers to the following question:

When learning supports (such as VLE and DISC) are made available, do the students use them, in what manner are they used, and can these supports be used to encourage deeper learning or even more independent learners?

The study builds on previous work (Lovatt et al., 2005), and also on a study of the effect of gender difference on students' approach to learning (Kelly et al., 2005). We attempt to draw together students' interaction with an organic chemistry module on VLE (*Moodle*), their interaction with the *DISC*, the approach they have adopted to their learning of chemistry, and their performance in the terminal end of year chemistry examination. Also we will discuss student trends of usage of the VLE, and relate this to their examination success.

Methodology

A chemistry module for first year students was selected for study. This module is taken by all first year students taking chemistry as part of their programme (approximately 200 students). The students taking this module have different backgrounds in terms of university entry points, programme of choice and prior knowledge of chemistry. Half of the module was organic chemistry and the other half was physical chemistry. Two learning supports were provided: the *Moodle* VLE and the *DISC*.

Learning supports

The VLE was only made available for the organic section of the module, thus all analysis relating to the provision of the VLE learning support is in relation to the organic part of the module (see Figure 2 for time line). All students had previous experience of Moodle in a biology module in the first semester, accessing lecture notes, online tutorials and sample exam problems and answers. The material provided on Moodle for organic chemistry consisted of weekly self-test quizzes, lecture notes, tutorial questions, discussion forums and links to relevant sites.

A *DISC*, modelled on Maths Learning Centre (Byers, 2006), was made available to all first year science students. This was open for 3 hours per week during the last 6 weeks of the semester and then 3 hours per day during the two week exam study break. The *DISC* was staffed by post-graduate students (tutors) in chemistry, physics and biology. Students were able to go to the clinic and ask questions relating to their course material. Students were expected to come with specific questions to the clinic, thereby encouraging them to go through their course work and seek answers to difficulties as they arose. The *DISC* had a very informal atmosphere, and if large numbers of students were present at the same time, group work and peer teaching was encouraged.

Evaluation methodology

Moodle logs were used to access patterns of usage of each resource by the students. Student surveys (pre module and post module) and informal discussions with the students generated data on students' opinions of the resources provided. Approximately 60% of the registered students completed the pre module survey (Pre102) and 48% of students completed the post module survey (Pst102). It is noted that the surveys were completed by those students who attended lectures on a particular day, and thus the data may not be completely representative of the whole sample cohort.

The evaluation of the *DISC* is based on attendance records, subject areas requested and feedback from the tutors involved.

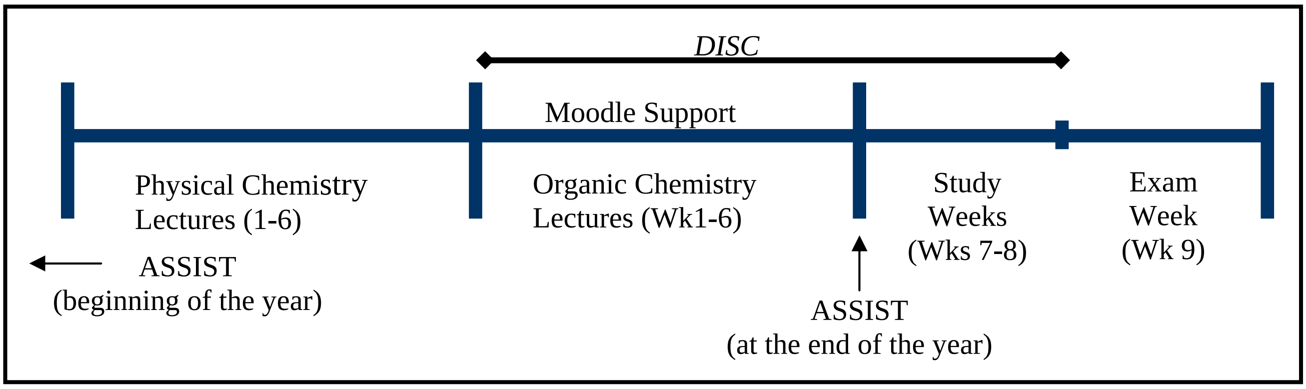
Students' approaches to their learning of chemistry were determined, using ASSIST, at the start of their first year and in their final week of their first year. Evaluation of the ASSIST data was carried out in SPSS following the guidelines for use of the inventory. The Cronbach's alpha value was recorded for the validation of the internal consistency of the three approaches to learning with the student cohort. All the approaches have an alpha value >0.7, which indicates good internal consistency (see Table 1).

Table 1. Cronbach's alpha values for internal consistency for approaches to learning subscales.

Cohort	Deep	Strategic	Surface
04/05	0.84	0.87	0.77

A time line of provision of learning supports, examination time and collection of ASSIST data is shown in Figure 2.

Figure 2: Provision of learning supports and collection of ASSIST data.



Results and discussion

The evaluation of student usage of Moodle was examined through the following questions:

a. *Will students use the extra support available through Moodle, and if so, which supports do they favour?*
b. *Do students who access the support material do better in examinations?*

Will students use the extra support available through Moodle and if so, which supports do they favour?

Of the 199 students registered for the module, only twelve students did not log on to Moodle at all. There were 12,179 student log hits on the site associated with the 187 Moodle users.

The Pst102 survey (N=96) provided a general overview of student participation. Most (97.9%) of the students had accessed Moodle at least once over the duration of the module; 2% accessed Moodle several times a day, 27% of the users accessed Moodle once a day, and 59% accessed the module once a week, with 12% accessing Moodle once a month/seldom.

Two of the students in the survey sample had not used Moodle for the module. One claimed to be too busy with other modules to use it and the other did not give a reason. The majority of Moodle access was made on campus (77%). Student access varied between college hours (52%) in the evening (40%) and at the weekend (8%). The key positive aspects of Moodle that students identified were: accessibility to lecture notes outside of lecture time (32%), after hour access (25%), off-campus access (24%), and instant feedback from the quizzes (19%).

Table 2: Total resource hits (N=199).

Resources	No. of students	Hits
Lecture notes	177	2993
Quizzes	147	3353
Tutorial Q's	137	868
Web links	*	533
Forums & Disc.	*	578

* Specific student numbers for these were not analysed using Moodle logs as the numbers involved were very small.

An indication of overall usage can be obtained from the log of hits (see Table 2). However, caution must be taken when discussing hits, due to the fact that some students accessed particular resources several times. The number of hits is given to demonstrate the general level of interaction students had with each Moodle resource, and further analysis of the individual hits is required to determine the actual activity with respect to numbers of students. Weekly quizzes had the most hits, followed by lecture notes and tutorial questions. However, lecture notes were the most accessed resource, based on the number of individual students who accessed the resources, followed by quizzes and then tutorial questions.

A breakdown of student hits per resource during the 6-week organic course is shown in Table 3. It is evident that resource usage generally decreased as the module continued. This is especially noticeable in relation to quiz access, where for quiz 1 (week 1), there were 1608 hits and for quiz 4b (in week 6) only 154. Interestingly, the tutorial question access was greatest for tutorial 5 in which both questions and solutions to all previous tutorials were provided.

Table 3: Moodle usage illustrating hit per resource used throughout the module.

Resource	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Lecture Notes	590	482	582	556	425	358
Quizzes	1608	604	400	371	219	154
Web-links	178	96	101	82	76	-
Tutorial Questions	208	164	147	120	229	-
Discussion Forums	293	-	139	-	146	-

Patterns of usage

The pattern of student access to lecture notes and quizzes could be determined from Moodle logs. Data (Figures 3-5) is shown for weeks 1-9 where weeks 1-6 correspond to the weeks of lectures, weeks 7-8 correspond to study break and week 9 is the exam week.

Lecture notes

Figure 3 shows a two-peak general trend in student access to the resource. Firstly, there is a peak in access corresponding to the week of the lecture when the notes became available. Access generally drops off quickly after this. However, lecture note access rises significantly again at week 6 up to week 9. The average number of accesses per student was 1.9. Overall, the number of hits per lecture note is on average 1.6 times greater than the number of students accessing the notes. This indicates that students do not necessarily download the lecture notes when they access the resource, as some are accessing it repeatedly.

Figure 4 shows the number of students who are accessing lecture notes for the first time in the respective weeks of the module. It is evident that the majority of first access takes place in the week the resource was made available, however, there are still students accessing the notes in the study and exams weeks for the first time.

Figure 3: No. of Students Accessessing Lecture Notes

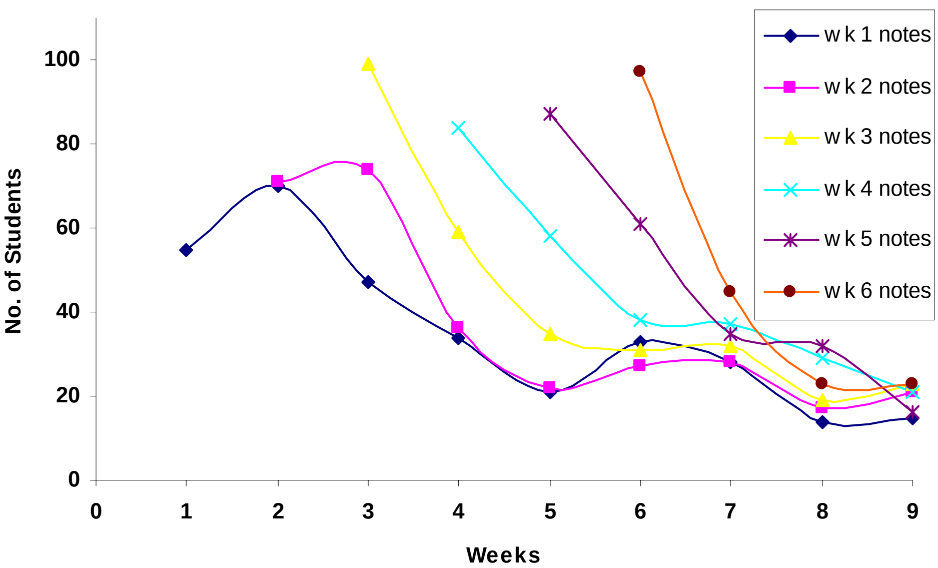
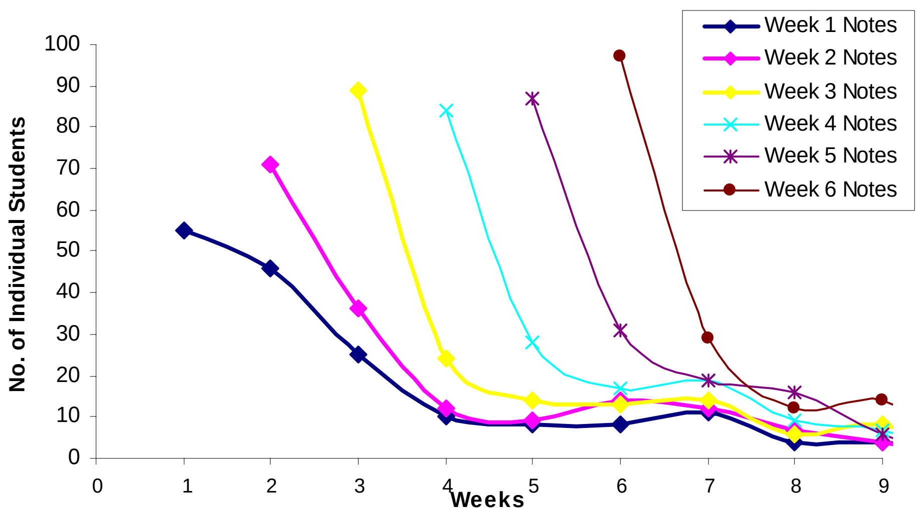


Figure 4: No. of Individual Students First Access to Lecture Notes



Clearly two points can be made here: firstly, more than half of the student cohort used the on-line support to access the lectures notes during the lecture period, but secondly, there were significant numbers of students accessing these resources for the first time at exam time.

Quizzes

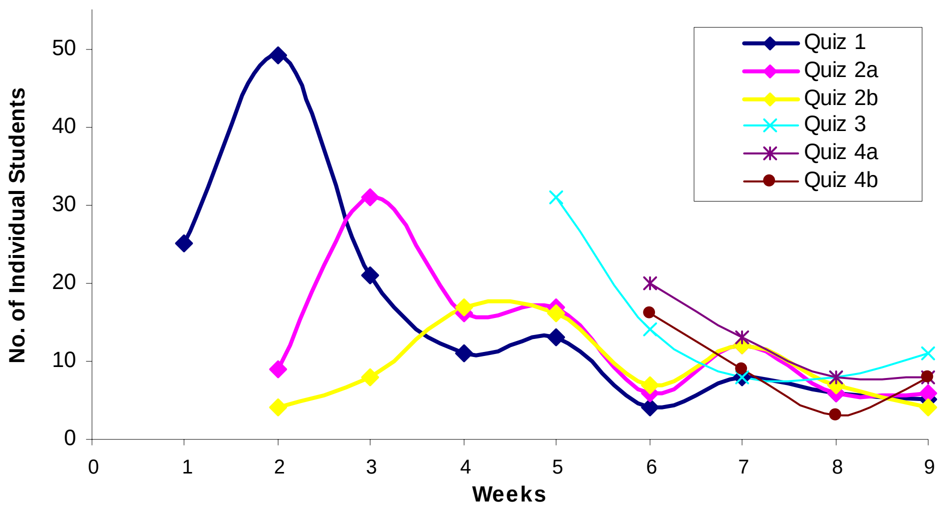
Quizzes were made available to students on Moodle but were not used for formal assessment. The pattern of quiz access is shown in Table 4. It is noted that quiz usage substantially decreased during the module. Students only received solutions to the quizzes if they submitted their answers. From Table 4 it is clear that many of those who accessed the quizzes did not submit their answers. It is not clear why students who went to the trouble of accessing the quizzes did not submit them; it may simply be that the students found them either too easy or too difficult. The fact that the quiz usage decreased during the module would support the latter explanation.

Table 4: Quiz usage (number of students).

Quiz	Accessed	Submitted	% Accessed	% Submitted
Quiz 1	140	91	70.3	45.7
Quiz 2a	99	52	49.8	26.1
Quiz 2b	71	38	35.7	19.1
Quiz 3	68	31	34.2	15.6
Quiz 4a	49	25	24.6	12.6
Quiz 4b	35	16	17.6	8.0

The pattern of first access to each quiz is shown in Figure 5. New quizzes were made available in weeks 1 (Quiz 1), 2 (Quiz 2a and 2b), 5 (Quiz 3), and 6 (Quiz 4a and 4b). Interestingly, the quizzes were not used very much during the exam study weeks. However, the two peak trend is noticeable; the first peak corresponds to the week the resource has become available, and the second during the study and examination weeks. It is evident that the first peak in this trend decreases for the later quizzes, highlighting students waning interaction with the quizzes in the later weeks of the module.

Fig 5: No. of Individual Students First Access to Quizzes (CS102)



Do students, who access the support material, do better in examinations?

The final examination consists of two sections, one in organic chemistry and one in physical chemistry. As there were no Moodle resources available for the physical chemistry section of the module, it was considered a reasonable comparison to determine if students who accessed Moodle did equally well in both sections.

In Table 5, the mean number of resources accessed by students who passed the module (i.e. scored >40%) are compared to those who achieved a mark <40%. The mean is also shown for the two sections of the examination paper (the organic and physical) and the associated p values indicate that the differences are statistically significant.

Table 5. Student overall exam success and comparison to mean resources used.

CS102	Score	N	Mean no. resources used	t-value	p-value
Overall	>40%	137	10.55	4.146	0.000*
	<40%	44	7.57		
Organic	>40%	123	10.51	3.3341	0.000*
	<40%	58	8.38		
Physical	>40%	141	10.43	4.121	0.000*
	<40%	40	7.70		

Note: T-test and Chi-squared analysis are used to determine correlations between student performance in examinations and their usage of Moodle. T-test analysis is further used with the ASSIST inventory. For this data, 'p' values are quoted; 'p' values below 0.05 are significant to 95% confidence and values below 0.01 are significant with 99% confidence.

From Table 5, it is clear that students who accessed more resources tended to do better in both parts of the examination. This could indicate that the more conscientious or motivated students will use whatever resources are available, or indeed that these students would have succeeded anyway, even if the resources had not been available.

Interestingly more students passed the physical chemistry section than the organic section of the end of module examination. Analysis of the type of questions asked showed that students were required to answer mainly calculation type questions in the physical chemistry section, while they had to devise reaction sequences in the organic section. This may have been a contributing factor to the greater success rate in the physical section as a student could achieve high marks in this section by carrying out calculations correctly. Also, the calculation questions were similar to those already performed in lectures and tutorials. The organic section, on the other hand, required linking several different parts of the lecture course together to answer the questions correctly.

Another significant factor in examination success was the students' prior knowledge of chemistry before entering university. It was found that students with prior experience of chemistry at 2nd level (Leaving Certificate Chemistry) outperformed students who hadn't done chemistry before (p=0.000). Performance on the organic section of the exam was significantly based on whether students had Leaving Certificate Chemistry or not (p=0.0000, Chi-squared = 20.24). 82% (N=82) of those with Leaving Certificate Chemistry, passed the organic section whereas only 51% (N=41) of those without Leaving Certificate Chemistry passed this section.

Accessing lecture notes has a significant positive correlation with examination performance in the organic section. For the individual weekly lecture notes, weeks 1, 3, 4, 5 and 6 showed a significant positive correlation between those who accessed the notes and those who didn't, in relation to their organic exam performance (see Table 6). It is worth noting that this data only considers whether the students had accessed the resource themselves; it does not account for students receiving copies from others or even if students actually used the resource in their learning.

Table 6. Performance in organic chemistry in relation to lecture note access.

Resource	Proportion of students who passed the organic chemistry exam [b]		Chi-squared values	p values
	Accessed	Not Accessed		
Wk1 notes	70% (N=167)	43% (N= 14)	4.39	0.036
Wk3 notes	70% (N=164)	41% (N= 17)	6.18	0.013
Wk4 notes	70% (N=162)	43% (N= 19)	4.59	0.036
Wk5 notes	73% (N=156)	36% (N= 25)	13.60	0.000
Wk6 notes	71% (N=150)	52% (N= 31)	4.59	0.032

[b] % value in table refers to % of N value (e.g. 70% of the 167 students who accessed week 1 notes passed the organic section of the examination paper while only 43% of the 14 students who did not access the same notes passed).

Likewise, quiz access was significant in terms of organic examination success (Chi-square = 10.35, p=0.008). 74% of those who accessed the quizzes passed the exam (N=144) and 54% of those who didn't access any of the quizzes scored below 40% (N=37). The students who passed the exam accessed an average of 2.8 quizzes, and those who scored below 40% in the exam accessed an average of 2.0 quizzes.

Quiz attempts versus exam performance was further examined with respect to students' prior knowledge of chemistry. Students with higher level Leaving Certificate Chemistry who attempted Quiz 1 did significantly better in their module exam (p=0.038) than those who didn't attempt the quiz. There was no other significance for the remaining quizzes for this cohort. Students without Leaving Certificate Chemistry who attempted quiz 1 and 2a did significantly better in their module exam than those who didn't (Table 7). These differences were also observed for the remaining quizzes but the magnitudes of the differences were not statistically significant.

Table 7. Non Chemistry Leaving Certificate students' exam performance in relation to quiz access.

Quiz	Usage [a]	N	Mean % overall exam	Mean % Organic	Mean % Physical	CS102 Sig	Organic Sig	Phys Sig
Quiz 1	Didn't	42	39.2	36.0	42.5	0.015*	0.050*	0.016*
	Did	36	49.5	46.1	52.9			
Quiz 2a	Didn't	60	40.8	37.0	44.5	0.005*	0.010*	0.017*
	Did	18	54.6	56.6	56.7			

[a] Did/ Didn't refers to quiz access

***Drop-in-Science Clinic* (*DISC*)**

DISC was available to the first year students during the last six weeks of the semester and for the two week study break before the examination. Only eighteen students attended during the semester, averaging two visits per student (actual number of visits varied from one to four). During the study break 32% of the first year students attended. Interestingly these students were from all levels in the class – first class honours students as well as those who had failed first semester examinations. Only 26% of the attendees had failed the first semester examination. Therefore, it had a broad range of appeal.

While 17% of the students who visited the clinics did so on at least five occasions during the study break, and many stayed for several hours, 37% visited only once. These students, who visited only once, arrived with specific problems and generally left confident that they had resolved their issues. The areas where student questions arose were 61% chemistry, 28% physics and 11% biology.

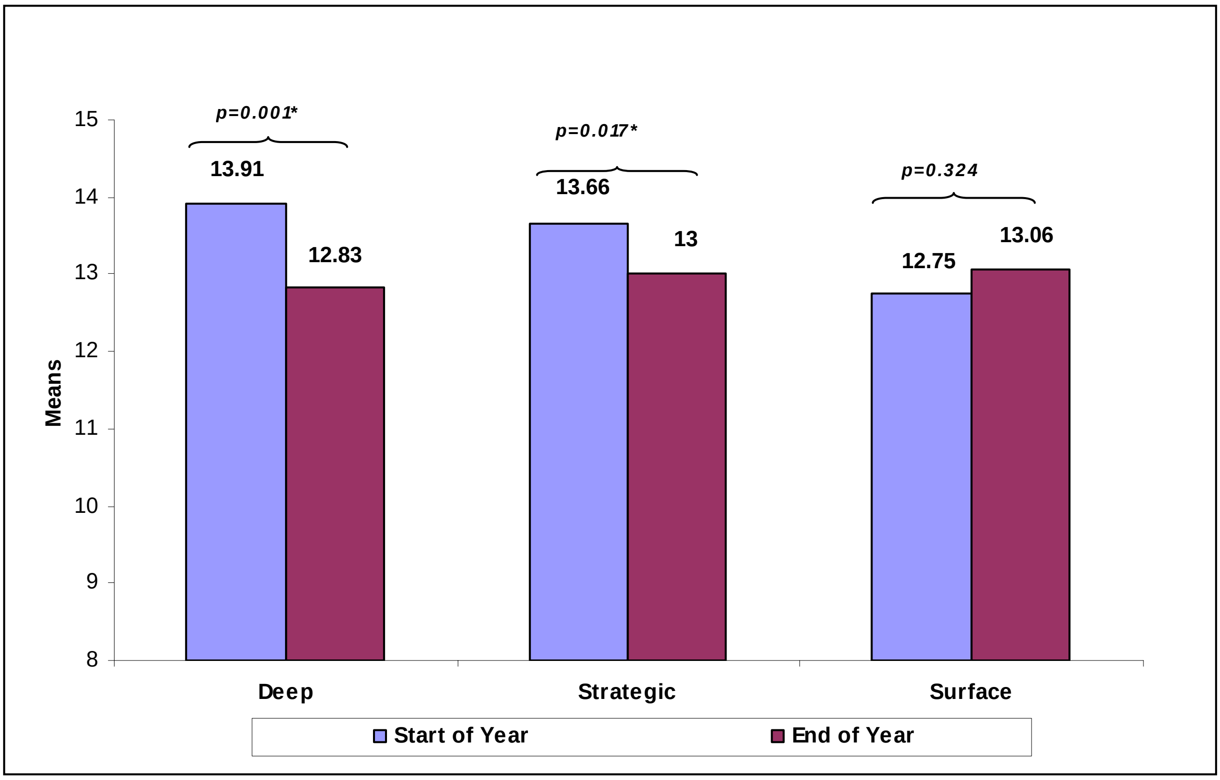
It is difficult to measure the effect of the clinic on examination performance. However, feedback from the students was favourable in that the students who attended them liked them.

From the learner's perspective, the question arises as to whether such initiatives encourage students to engage only at exam time. Students' questions asked at the *DISC* were generally focussed on specific past examination paper questions. This in itself may not be unusual before an examination; however, it was noted by the tutors that it was evident that the students' focus was on obtaining the answer rather than on obtaining any detailed explanation/background to the chemistry involved. Of the students who attended the *DISC*, 27% had not attempted the quizzes that were available on Moodle. Some students had a selfish approach, displaying a 'help is available – it's all for me' attitude. It was not uncommon during the study break for students to enter the *DISC* with all their notes and ask the tutor to tell them what sections were needed to pass the exams.

ASSIST data and discussion

The students taking the 1st year organic chemistry module completed the ASSIST inventory in week 4 of semester 1 (beginning year) and in week 12 of semester 2 (end year), after they had completed the organic module. Figure 6 shows the mean values obtained for each approach.

Figure 6. Paired t-test analysis of learning approach during 1st year chemistry using ASSIST survey.



Week 4 data shows that students scored deep and strategic approaches to learning above that of a surface approach. This indicates that incoming students are regarding themselves as having a deep approach to their learning rather than a surface approach. There was a statistically significant difference at 93% confidence between a deep and surface approach (N=74, p=0.064). There was no other significant difference between any of the other approaches noted.

By the year end there was no significant difference noted between the three approaches; however, paired t-test analysis highlighted changes in students approach between the beginning and end of the year. Results clearly show that students adopted less deep and strategic approaches and more surface approaches to learning chemistry as the year progressed. The changes in deep and strategic approaches to learning were significant; N=53, p=0.001 and N=50, p= 0.017 respectively. Though there was an increase noted in the surface approach, this change was not found to be significant, N=52, p=0.324 (Figure 6).

The change in learning approaches between the beginning of the year and the end of the year can be related to significant changes in the learning subscales (see Table 8). There is a significant decrease noted in the subscales ‘seek meaning’ and ‘relating ideas’; these changes in the subscales relate to students taking a less deep approach (relating ideas and use of evidence) than when they first entered university. There is also a significant decrease in the strategic subscale ‘time management’ which relates to students being less organised in managing their study time. The final noted significant subscale change is ‘syllabus boundness’. There was an increase in this surface approach subscale indicating that students had a greater tendency to concentrate only on the material covered in lectures when studying chemistry towards the end of their first year.

Table 8. Paired t-test analysis of learning subscales during 1st year chemistry.

Subscales	Mean Score		p -value
	Week 4	Week 24	
Seek meaning	14.51	12.93	0.000
Relating ideas	13.71	12.51	0.005
Use of evidence	14.64	12.86	0.000
Time management	12.96	10.96	0.000
Syllabus boundness	13.96	15.70	0.000

Conclusions

First year students have many additional demands on their time beyond lecture courses, including part-time work and social life; therefore the time that they are willing to spend studying is limited (almost 63% of the cohort had part-time jobs with 50% of these working 15 hours or more in part-time employment). Additionally, there is a tendency for students to concentrate their study into exam study weeks rather than engaging with the material throughout the semester. Several additional resources were made available to them, namely resources on Moodle and a drop-in-science clinic (*DISC*) to allow the students the opportunity to fit in their study at times suitable for them.

Students generally liked the Moodle support. They identified ‘ease of use’ and ‘accessibility’ as positive aspects of the support. Their preference for each resource was reflected in their usage. Lecture notes, quizzes and tutorials were predominately used and students requested more solutions to be available on the support, including past exam papers, worked tutorial questions, quizzes and assignments.

However, usage of the support generally decreased as the module progressed. This was especially noted with fewer students accessing resources made available in the later weeks of the module. Lecture note access was predominately in the week that it became available. There is a second peak of access noted in the study and exam weeks. This 2nd peak of access includes both students who are accessing the resource for the first time and repeat users. It was noted that there was a number of students who accessed lecture notes for the first time in the exam week. Like lecture notes, the majority of the cohorts’ access to quizzes was made in the week the quiz became available. It is noted that the level of this access greatly decreased with respect to the later resources. Quiz 1 was accessed 140 times, but the final quiz, Quiz 4b, was only accessed 35 times.

Students who interacted with the module supports did better in their exams. However, it is not suggested that it is as a direct result of the provision of the support. It is merely an indication that students who were motivated/interested in using all available help in their studies did better in their examinations. It was observed that in particular, the effect of interacting with the on-line quizzes was more pronounced for students without Leaving Certificate Chemistry than for those with Leaving Certificate Chemistry. A Virtual Learning Environment (VLE) provides an additional source of course material and is accessible; these are the features that students like and they have now come to expect to be available to them. The experience of the Drop-in-Science Clinic (*DISC*) supports the belief that students do wish to succeed in the examinations. However, the fact that significant numbers access material for the first time only during exam weeks, that they don't interact with supports available until exam weeks, shows that we must use the VLE and other supports in a way that is much more beneficial and encouraging to the student. Many like the idea of lecture notes being available on VLE – so that there is security in knowing they are accessible at any time. Coupled with the changing approach that is adopted over the year, it appears that this is not the way to encourage independent learning in students.

The implication of this work is that efforts must be made to encourage more student interaction with their respective courses in conjunction with encouraging students to adopt a deep approach to their learning. It is suggested that this may be achieved through tutorials, interesting and lecture-linked laboratory sessions and through continuous and suitable assessment methods. The VLE initiative is currently being developed for use as a continuous assessment tool as well as a support for student learning. At present, links between student approaches and individual patterns of access to Moodle are being investigated and will be reported on in the future.

References

Bell M., Bush D., Nicholson P., O'Brien D. and Tran T., (2002), *A survey of online education and services in Australia*, [online: https://www.ucisa.ac.uk/groups/tlig/vle/vle2003.pdf] (last accessed June 2007)

Biggs J., (1979), Individual differences in study processes and the quality of learning outcomes, *Higher Education*, **8**, 381-394

Boyle T., Bradley C., Chalk P., Jones R. and Pickard, P., (2003), Using blended learning to improve student success rates in learning to program, *Learning Media and Technology*, **28**, 165-178

Browne T. and Jenkins M., (2003), VLE surveys: A longitudinal perspective between March 2001 and March 2003 for Higher Education in the United Kingdom, [online: https://www.ucisa.ac.uk/groups/tlig/vle/vle2003.pdf] (last access March 2007)

Byers, B. (2006) *Developing independent learners in chemistry*, Report from ECTN Working party, [online:http://www.cpe.fr/ectn-assoc/archives/lib/2006/N03/200603_DILC_FinalRep2006.pdf] (last accessed June 2007)

Entwistle N., (2000), Promoting deep learning through teaching and assessing conceptual frameworks and educational contexts [online: http://www.ed.ac.uk/etl/docs/entwistle2000.pdf]

Fensham P., (2004), Engagement with science: an international issue that goes beyond knowledge, Paper presented at SMEC 2004, Dublin [online: http://www.dcu.ie/smec/plenary/Fensham,%20Peter.pdf]

Higher Education Authority, (2004), Creating Ireland's knowledge society: proposals for higher education reform, *HEA*, Dublin

Kelly O., Finlayson O.E. and Wilson, A., (2005), *Investigation into gender differences in approach to learning of undergraduate science students*, In R. Pinto and D. Couso, (Eds.), Proceedings of the

Fifth International ESERA Conference on *Contributions of research to enhancing students' interest in learning science*, Barcelona, Spain.

Lovatt J., Finlayson O.E. and James P., (2005), *Development and evaluation of approaches to student teaching and learning of chemistry at tertiary level using a VLE platform,* In R. Pinto and D. Couso, (Eds.), Proceedings of the Fifth International ESERA Conference on *Contributions of research to enhancing students' interest in learning science*, Barcelona, Spain.

Marton F. and Saljo R., in Ramsden, P., (1992), *Learning to teach in higher education*, p. 45, Routledge..

Ramsden P., (1992), *Learning to teach in higher education*, p. 42, Routledge.

Rogers, G., (2004), History, learning technology and student achievement. Making the difference, *Active Learning in Higher Education*, **5**, 232-247

Sharpe R., Benfield G. and Francis R., (2006), Implementing a university e-learning strategy: levers for change within academic schools, *ALT-J, Research in Learning Technology*, **14**, 135-151