# *Online conversations around digital artefacts: the studio approach to learning in STEM subjects*

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## Abstract

Studio-based learning provides a model that can be adapted for online learning. In conventional teaching settings, studio-based learning follows an apprenticeship model where students work independently or in groups, under the guidance of a tutor, using real-world activities. The 'Using OpenStudio in STEM learning' project has been established to evaluate the use of online studio-based learning in the Open University (UK). This paper reports our findings from the first two phases of the project which gathered data from educators who present the modules and also from a survey of students. Educators representing distance learning modules from a range of STEM disciplines including Computing and IT, Design, Engineering and Environmental Technology participated in a workshop to share information about the use of OpenStudio on their modules. A simple model of OpenStudio activities was derived from the workshop to illustrate the process of 'showing and sharing', viewing and reviewing', commenting and critiquing', and 'reviewing and reflecting' involved. Two Computing and IT undergraduate modules were then selected for more detailed analysis, one at level 1 (first year) and another at level 3 (third year). Both quantitative and qualitative data were gathered from samples of students on these modules and analysed. Comparisons between the OpenStudio model, the survey findings and Kolb's Experiential Learning model (1984) revealed the range of student views and the diversity of students' experiences of the learning activities, and provided some thought-provoking insights into student behaviour in carrying out the OpenStudio activities.

The data suggest that students enjoy the OpenStudio activities, especially the visual nature of artefacts and the idea that shorter comments may be made, rather than longer more discursive pieces of writing. In addition to learning about their subject area, students are also learning how to give feedback to their peers and how to use the feedback they receive, both of which are important skills. Many students are confident in their own ability and are able to evaluate the feedback they receive. However, some students may lack confidence in their own ability to give feedback on the work of their peers, particularly at level 1. Importantly, there needs to be an opportunity to complete the cycle of the experiential learning model in the activity by allowing students to produce another artefact. The experiential nature of the online studio activity presents an opportunity for students to reflect-in-action as well as reflect *on* their actions (Schön, 1983).

## Keywords

studio-based learning, peer feedback, collaborative learning, social learning, online learning, networked learning, Science, Technology, Engineering, and Mathematics (STEM).

## Introduction

Skills such as communication, teamwork and critical thinking are becoming increasingly important, and are in demand by employers in the Computing and IT industry (CBI, 2012). As more people work in project teams which may be distributed geographically, these skills need to be developed in online collaboration environments. Studio-based learning has been proposed as a model that can be adapted to online collaboration. It is an apprenticeship model with its origins in the arts; students work individually or in groups, share a space where they can follow others' work, and discuss ideas as work evolves. The Open University (OU), UK, developed an online studio environment, OpenStudio, that enables students to create and upload audio-visual



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resources and to engage in peer feedback through commenting facilities. Now incorporated into the Moodle virtual learning environment, OpenStudio is available to other institutions. The project 'Using OpenStudio in STEM learning' was set up to identify the different uses of OpenStudio at the OU, to explore views from tutors and students on its use, and to assess its value to students' learning. This paper reports on the two initial phases of this project – an educator workshop and collection of data from students – and discusses the findings to date.

# Studio-based learning

The studio-based learning approach has its origins in face-to-face contexts in Fine Arts and Architecture (Bayer, 1975). This apprenticeship model was later adopted as an important constituent of Design teaching in further and higher education (Schön, 1987). In studio classes, students are presented with a problem modelled on real world design practice and work individually or in groups to solve it. Sharing a physical space means that they can observe each other's work in progress, discuss ideas and help each other as work progresses and ideas evolve. In structured learning activities, students are asked to present their work for evaluation by tutors and peers, sharing and discussing their creative processes with them. Schön (1983) refers to this cycle as 'reflection-on-action' and 'reflection-in-action'. In studio-based learning the process of creating an artefact (for example a design prototype or an early version of a product) and the activity of presenting work for evaluation by tutors and peers can be viewed as following in terms of Kolb's Experiential Learning cycle (1984) following the stages of Concrete Experience, Reflective Observation, Abstract Conceptualisation and Active Experimentation. The experiential learning model can be applied to learning in a group as well as to individual learning.

Studio-based learning is a form of problem-based learning so students need to be taught the iterative process of generating, refining and evaluating possible solutions (Cennamo et al, 2011). As an active form of learning that involves students collaborating with their peers and the development of communication skills, it can be used effectively in STEM subject areas and there are studies on the use of studio-based learning in fields such as petrology (Perkins, 2005) and Human Computer Interaction (HCI) education (Hundhausen et al, 2012).

In an online context, Web 2.0 tools can support the creation of artefacts by learners and their active engagement in collaborative tasks involving knowledge building. The use of these online tools is most effective when used in conjunction with the appropriate teaching and learning strategies (Lee et al, 2008). Literature discussing studio-based learning in online environments is limited and mainly relates to Design (e.g. Jones & Lloyd, 2013), although issues around peer comment in an online studio environment are explored in Thomas et al (2014).

## Learning in an online studio environment

OpenStudio is an online studio environment developed by the OU. In OpenStudio each student has a space to upload artefacts and view the artefacts uploaded by other students; comments can be added to each artefact by students. In online studio environments, students can learn from each other's work in a digital, networked context. We contend that it is possible for students to carry out similar processes to those that take place in the physical studio, such as identifying the 'quality' features of works in progress, comparing their fellow students' work with their own and giving, receiving, and reflecting on feedback.

As a distance learning institution, OU students study modules which build towards higher education qualifications. Teaching and learning materials include printed and electronic study texts, audio-visual material, a virtual learning environment, asynchronous online forums and synchronous web conferencing facilities. OpenStudio was first used in 2007 as part of a short module on *Digital Photography* and it forms a key component of the first year *Design Thinking* module. Student participation in the environment was very high in both modules and OpenStudio was well received by students:

> "The open design studio where the students post their work is brilliant as it's so simple to use, therefore the interaction between students is frequent and the feedback given is really useful." (feedback from a Digital Photography student)

The level of meaningful engagement and interaction within OpenStudio surprised even the educators:

> "A genuine personal relationship is generated between students and this environment and it provides critical places within which they can begin to present and enact their ideas as design thinkers." (Jones & Lloyd, 2013 p9).


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The success of OpenStudio in the Digital Photography and Design modules meant that other modules also adopted it, using the environment for a range of different purposes. The 'Using OpenStudio in STEM learning' project was set up in 2014 to identify the different uses of OpenStudio at the OU, to explore views from both tutors and students on its use, and to assess the value of its use to students' learning.

## Project Phase 1 – Workshop for educators for module teams

As a starting point for the project, a workshop was held for educators involved in OU modules using OpenStudio. These educators were the module chairs (or a similar module representative) with overall responsibility for the design and running of the modules. The educators were asked to give brief presentations on: how OpenStudio was used in their module; the rationale for using OpenStudio, and the approach taken; the benefits and issues of using this environment. The aim of the workshop was to gather information on the range of different educational uses of OpenStudio, and to share experiences. A brief summary of the information from individual modules is given in Table 1.

**Table 1 Summary of the data from the module team chair's workshop**

| Discipline | Activities and assessment |
|---|---|
| STEM access module (Y033) | Students upload images of their module work e.g. a photograph of a model bridge they have built. They comment on their own images. The activity is assessed. |
| Digital photography (level 1 course) (T189/TG089) | Students upload photographs in each of 10 weeks. Other students add evaluative feedback comments. Weekly activities are not assessed but final work is. |
| Design level 1 (U101) | Students upload images of their designs for peer comment throughout the module. 42 uploads are required over 9 months. Only one assignment directly assesses use of OpenStudio. |
| Design levels 2 & 3 (T217/T317) | The aim is to develop a design community. Peer feedback is encouraged. OpenStudio supports reflective activities; used for individual project work at level 3. |
| Engineering level 1 (T174) | Students upload a relevant image and comment on each other's. They then work in small teams on a design task. Later tasks are more discursive. OpenStudio work is assessed throughout module. |
| Environmental Technology Management levels 2 and 3 (T219/T319) | Students post artefacts related to systems techniques and diagrams. They add textual descriptions, and comment on each other's artefacts. At third level, students work in tutor-led and student-led groups. OpenStudio work is not directly built into the assessment. |
| Computing and IT level 1 (TU100) | Students create and upload an audio-visual presentation, and comment on the presentations of at least two other students. The assignment assesses: the presentation, the feedback given to other students, and the reflection on how the student might use the feedback they received. |
| Computing and IT level 2 (M258) | Team working is central to this module. Some activities involve uploading documents as well as images. In the first assignment students share results of individual work. In the second they discuss their work and produce a team document. |
| Computing and IT level 3 (TM354) | Students upload diagrammatic models, comment on other students' models, and use the feedback received to improve their own model. Each assignment includes an OpenStudio activity, assessing these or related aspects. |

From the workshop we identified an initial model of learning activities in the online studio environment:

- *Showing and sharing* – students upload a digital artefact, such as a photograph or a graphical image, and display it to their peers;
- *Viewing and reviewing* – students look at the work of other students and review their own work in comparison to that of others;
- *Commenting and critiquing* – students are asked to evaluate the work of other students and give them feedback in the form of comments; and
- *Receiving and reflecting* – students receive the comments of other students, reflect on the comments and then think about how they might improve their own work.


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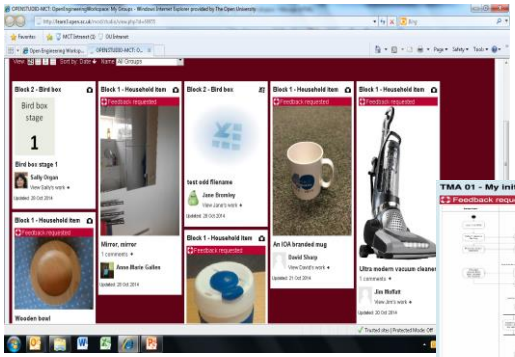
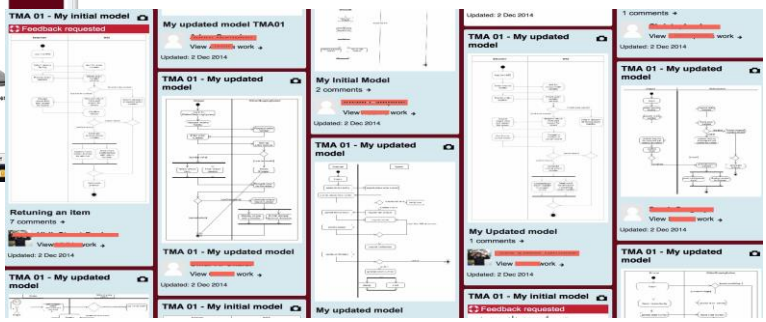
The first two types of activity, ‘showing and sharing’ and ‘viewing and reviewing’ are common to all the modules, but use of the ‘commenting and critiquing’ and ‘receiving and reflecting’ activities depend on the learning design of particular modules. For example, both the level 1 and level 3 Computing & IT modules (TU100 and TM354 complete all the activities, but in the STEM access module Y033 students are just asked to view the work of their peers. OpenStudio also provides a means of collecting and curating digital artefacts for the duration of a module so students can look back over their work. Also, there is the potential for use in individual and group project work and for the development of team-working skills.

Significant points were made at the workshop concerning the visual nature of the artefacts, encouraging students to engage with the activity by viewing the artefacts and making comments. In addition, the visual nature of the artefacts and the relatively short comments makes a refreshing change from typically longer text-based exchanges in forums and wikis. The visual nature may present accessibility issues, but students should be encouraged to provide descriptions of images, which is good practice for web-based images. Workshop participants emphasised the importance of providing guidance to students on giving feedback to their peers. Participants reported that module tutors are not always happy with the depth of reflection and the quality of feedback provided by students. Finally, aligning the different stages in commenting activities to a specific time frame is helpful to ensure that students receive peer feedback at appropriate times. Figure 1 shows examples of the way in which OpenStudio is used in a level 1 Engineering and in a level 3 Computing & IT module.



(a) Level 1 Engineering



(b) Level 3 Computing & IT

**Figure 1 The use of OpenStudio in two distance learning modules**

## Project Phase 2 – Collecting data from students

The OU’s student cohort is very diverse demographically. Also, the university’s open access policy means that students do not need to have qualifications or experience of a subject before enrolling so there is diversity in terms of skills and experience. The participants in this research were students studying either the level 1 (first year undergraduate) Computing and IT module TU100 or the level 3 (third year undergraduate) Computing and IT module TM354 (see Table 1). These particular modules were chosen partly because they both the artefact and the peer feedback activity in OpenStudio were assessed in their learning design and because some members of the project team were actively involved in the modules, which made access to samples and information convenient. For both modules, students usually work in groups of twenty led by a tutor, although at level 1, students were allocated to small groups of four to six for the OpenStudio activity.

In the level 1 module, students use audio and image processing tools to create an audio-visual presentation, which they upload to OpenStudio. Students are expected to view the presentations of others within their tutor group, and give feedback on the presentations of at least two other students. Students are assessed on their presentation and its storyboard and they are asked to provide evidence of the comments they make. They are

also asked to explain how they would use the feedback they received from other students in order to improve their presentations, but they are not required to actually change their presentations.

In the level 3 module, the OpenStudio activity was intended to help students learn how modelling is used within agile software development to share an understanding of a problem or of a solution. The activity also gives a feeling for agile working practices such as the daily stand up meeting to agree on what needs to be done. Students were asked to develop an artefact which was either a model of a domain problem or of a software solution. Students were expected to comment on the work of at least two students, reflect on the feedback received and change their models based on the feedback and their reflections.

## The student survey

Samples of 500 students from the level 1 module and 300 students from the level 3 module were invited to participate in an online survey about their use of OpenStudio. The survey was administered by the Student Survey Team at the OU, using an email invitation containing a link to the questionnaire. The email was sent after students had completed one assessment associated with OpenStudio activity. The survey consisted of 11 questions in total, with students invited to give a response using radio buttons and a text box for comments associated with each question. Initial questions in the survey asked for students' views on how the OpenStudio activity was presented to them, such as the clarity of the instructions and whether they felt adequately prepared to give feedback to their peers. Other questions asked about the student's own engagement with the activity, i.e. whether they had viewed the work of other students and commented on other students' work. Students were also asked whether they had received any comments from their fellow students.

Questions about learning from peers used a Likert scale (Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree) to indicate level of agreement with statements such as "My skills improved as a result of looking at other students' presentations or models" and "My skills improved as a result of receiving comments from other students." (The wording for the level 1 and level 3 students differed, to take into account the specific activity using OpenStudio, and its intended purpose). Other questions used a Likert scale to ask about: students' views on the value of giving feedback; whether they appreciated the diverse approaches to producing a presentation (level 1); whether they appreciated what it means to share an understanding of a model (level 3). The final question asked whether students had enjoyed the activity. At the end of the survey students were invited to make further comments. The free text comment boxes associated with the questions provided a semi-structured instrument for collecting rich qualitative data from the students.

The response rates to the survey were 19% ($n$ = 95) for the level 1 module and 13.6% ($n$ = 42) for the level 3 module. The survey administrators collated the quantitative data electronically. A qualitative analysis was carried out on the comments made by respondents, which helped to illuminate the findings from the quantitative data. We followed an iterative process of data reduction, data display and drawing conclusions (Miles & Huberman, 1994). Two researchers coded the set of comments from the level 1 module; and two different researchers coded the comments from the level 3 module. In each case the researchers identified reoccurring themes regarding students' responses to the use of OpenStudio. Following discussion between the researchers, a further iteration was carried out by the project team leader to produce an amended set of themes.

## Results of the survey

Both quantitative and qualitative data are reported together in this section as the qualitative data analysis provides a context and an explanation for the quantitative results.

Almost all respondents on both modules, 98%, had uploaded their artefact. Almost all respondents (90%) thought that the instructions for carrying out the OpenStudio activity were sufficiently clear. A large majority of the respondents from both modules (98%) viewed the presentations of more than one student. The majority of respondents (80% of the level 1 and 85% of the level 3 respondents) thought that they were adequately prepared to give feedback. A small number of level 1 respondents that they did not confident enough in their own knowledge to be able to comment on someone else's work.

97% of the level 1 respondents and 88% of the level 3 respondents had commented on the work of other students. 86% of level 1 respondents and 75% of level 3 respondents received comments from more than one of their peers. The very small number of respondents who did not receive any comments explained that they had not uploaded their artefacts in time for other students to see them and provide comments. A long interval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between posting their artefact and receiving feedback from their peers was a source of frustration on both modules. Some respondents, particularly those at level 3, preferred to study independently rather than collaboratively. Some really enjoyed the collaborative nature of the activity and their groups seemed to be working very well, but a small number of respondents found that group cohesion was lacking.

60% of level 1 respondents and 63% of level 3 respondents felt that their work had improved after viewing the work of other students; for example, they were able to compare their own work with that of their peers. Some respondents were less convinced of the value of learning by viewing the work of their peers, however (14% of level 1 respondents and 17% of level 3 respondents disagreed). 67% of the level 3 respondents agreed that they had learned from the comments they received from other students. The level 1 respondents were less convinced: only 55% agreed and the survey feedback from some students on both modules suggest that they preferred feedback from their tutor and were not sure that other students' comments were of a satisfactory standard. 80% of level 1 respondents agreed that they saw a diversity of approaches to producing the artefact. This is slightly less than the 85% agreement for the level 3 module, perhaps because the level 1 students are encouraged to use a media database for their presentations (although they were permitted to use their own resources), whereas the level 3 students were developing an actual model.

A key objective for the level 3 activity was for students to get a feeling for what it means to share an understanding of a problem or a solution. 77% of level 3 respondents agreed that they had gained this understanding after completing the activity; 13% were neutral, and the remaining 10% disagreed, for example, some students felt that they already understood it. At level 1, students were asked whether they understood the importance of giving feedback after carrying out the activity and 75% of level 1 respondents reported that they did; 4% disagreed and the remainder were neutral about the importance of giving feedback as, again, many respondents reported that they already understood the value of feedback.

Generally, students enjoyed the OpenStudio activity, partly as a refreshing change from more discursive writing; 73% of level 1 respondents and 67% of those at level 3 enjoyed it. Several level 1 respondents who had enjoyed the activity thought OpenStudio was a very good collaborative tool and expressed the wish for more of these types of activity. Of the 27% of level 1 students who reported that they did not enjoy the OpenStudio activity, some had a poor experience of using the software tools to develop the artefact. Others had experienced difficulty in uploading the artefact to OpenStudio, although the respondents acknowledged that sometimes this was beyond the control of the module team. At level 3, 33% of respondents reported that they did not enjoy the activity; some respondents adopted a very pragmatic approach, saying that they only completed the activity because it was part of the assessment, and some thought that other students were carrying out the activity in a perfunctory manner. A small number (2%) of students at both levels simply disliked the collaborative nature of the activity, partly because the timescale did not suit them but also because of the dependency on other students.

Students often made recommendations regarding improvements for the activity. Usually, these related to the user interface of OpenStudio, which they thought could be improved, and the choice of software tools for developing the artefact. Other suggestions related to the learning design of the activity, for example, respondents recommended that a more detailed schedule with interim deadlines should be given, to encourage participation at more regular intervals. Also several students recommended that there should be more iterations of activity to promote collaboration (e.g. at level 1, revise the presentations; and at level 3, repeat the modelling exercise).

## Discussion of findings

The OpenStudio activity for both sets of students in the study is a 'situated' learning experience (Lave & Wenger, 1991) involving a simulation of a real world activity, i.e. presenting work to one's peers, observing the work of others and giving and receiving feedback. This type of learning is well supported by theories based on constructivist epistemology and collaborative learning that view cognition as a social process (Brown et al, 1989). The findings from the study were explored in terms of the learning activities in the OpenStudio model derived from Phase 1 of the study: 'showing and sharing', 'viewing and reviewing', 'commenting and critiquing' and 'receiving and reflecting'. These learning activities were then compared with the stages of the Experiential Learning Cycle, namely, Concrete Experience, Reflective Observation, Abstract Conceptualisation and Active Experimentation of Kolb's Experiential Learning Cycle.

*Showing and sharing*


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In terms of the Experiential Learning Cycle, students undertake the Concrete Experience of producing the artefact and then displaying it to their peers: the *showing and sharing* stage of the studio-learning model. On the whole, students were enthusiastic about this activity; for example, they enjoyed the visual nature of the artefact.

*Viewing and reviewing*

The *viewing and reviewing* activity enables students to reflect on their own artefact by observing the different approaches adopted by their peers and comparing their own work with that of others. This facilitates the Abstract Conceptualisation of skills and knowledge by students.

The majority of students agreed that they had learnt from this process,

> "I viewed every single presentation submitted by my group. Not only was it interesting but it gave me ideas for any future efforts I will make in other courses." (Level 1 student)

Students appreciated the diverse approaches to developing the artefact taken by their peers,

> "It was interesting to see the variety of approaches to the problem - including some good ideas and a great many bad ones…" (Level 3 student)

*Commenting and critiquing*

In the studio environment, *commenting and critiquing* activity of providing feedback to other students may further enable the Abstract Conceptualisation process, as students consider the 'quality' features of each other's work and how it could be improved. Again, students actively participated in this phase of the activity. One respondent even said they had commented on the work of everyone in the group. However there was an issue of confidence in their own learning amongst a very small number of level 1 students who did not feel ready to comment on the work of their peers even within the confines of the tutor group. This issue adversely impacted their enjoyment of the activity.

*Receiving and reflecting*

Having received feedback from their peers, students are expected to consider how they might improve their own artefact: the *receiving and reflectin*g aspect of the OpenStudio model. This prepares them for the 'Active Experimentation' stage in Kolb's Experiential Learning Cycle. In our study most of the respondents felt that they had learned from this process,

> "The feedback was all positive and had some constructive criticism, all of which I was grateful for." (Level 1 student)

The students who disagreed that they had learned from their peers' comments said they preferred to receive early feedback from their tutor or that they lacked confidence in the competence of their peers.

A small number of students were dissatisfied with the peer learning approach and felt that they did not learn anything important from the activity. For example, some students were not convinced of the value of artefacts produced by their peers, e.g. they were sufficiently confident in their own skills and felt they had nothing to learn from their peers and also a very small number carried out the activities only because it was expected as part of the module. Two students complained that they lost one or two marks by following the advice of their peers. This suggests that the 'commenting and critiquing' and 'receiving and reflecting' aspects of the OpenStudio activity requires further development, partly to reassure participants of the value of peer comment, but also to ensure that students realise their own responsibilities and the impact that their comments might have on their peers. At this stage, the students are learning to become part of a 'community of practice' (Wenger, 1998) through 'legitimate peripheral participation' (Lave & Wenger, 1991) in an online community of learners focussed on a particular task. However, students need to be supported in developing their critical faculties to enable them to evaluate the work of their peers and the advice they receive.

Some level 1 students expressed dissatisfaction because the design of the activity did not allow them to complete the learning process by improving their model (just explain how they might do this).

> "It is a pity that you don't give enough time during the course to get students to revise their presentations after receiving feedback and viewing other students' concepts." (Level 1 student)

This suggests that OpenStudio activities should provide an opportunity to revisit the Concrete Experience stage of the Kolb model. The level 3 module activity did complete the learning cycle by allowing students to produce a revised model and share it on OpenStudio but, even then, some students thought there ought to be more iterations of the activity.

In Schön's (1983) reflective practitioner model, when unexpected problems arise, the practitioner may talk through the issues with a supervisor or a mentor in order to resolve them. In this situation, the student's tutor


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acts as the 'supervisor' or 'mentor' and, in the main, the 'unexpected problems' experienced by the student were either difficulties with software or lack of feedback from peers. Unfortunately, some students did not seek help from their tutor which could have ameliorated their experience of the activity. Thus, learning to seek help when needed from appropriate sources, such as a tutor, is very important aspect of students' learning.

# Conclusion

This study has illuminated a number of salient features of learning activities in the OpenStudio environment. The model developed from the module chair workshop suggests that there are different stages to the design of learning activities in OpenStudio: 'showing and sharing', 'viewing and reviewing', 'commenting and critiquing', and 'receiving and reflecting'. When we compared the quantitative data and the rich qualitative data from the survey with Kolb's Experiential Learning Cycle and the OpenStudio model we discovered that there are some interesting areas that are worth noting.

Both the quantitative and qualitative data suggest that students enjoy the OpenStudio activities, especially the visual nature of artefacts and the idea that shorter comments may be made, rather than longer more discursive pieces of writing. However, students may lack confidence in their own ability to give feedback on the work of their peers in an online environment, particularly at level 1. Importantly, there needs to be an opportunity to complete the cycle of experiential learning by allowing students to produce another artefact (or concrete experience) based on the processes of reflective observation, abstract conceptualisation and active experimentation in the Kolb model. Consideration also needs to be given to the timing and scheduling of the different phases of the OpenStudio activity.

In addition to learning about their subject area, students are also learning how to give feedback to their peers, and how to use feedback. The real world, experiential nature of the online studio activity presents an opportunity for students to reflect-in-action as well as reflect *on* their actions. The next stage of the project involves analysing the data from the cohort of tutors on both modules and also examining some of the students' artefacts in OpenStudio and the feedback on them given by student peers.

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