# A Collaborative Learning System for Sharing 3D Models: 3D Model Co-leaning Space

I-Sheng Lin, Tsai-Yen Li, Fang-Chi Liang, Yong-Teng Lin

***Abstract*—**In the recent years, due to the prevalence of 3D printers, there have been many applications of 3D printing developed for education such as creating custom-made teaching aids or student art work. Although there are web sites hosting 3D models created by students and allowing them to share and search in the database, these systems usually lack functions of collaborative learning. On the other hand, most learning management systems do not provide functions needed for sharing and viewing 3D models. In this work, we aim to design a system called *3D Model Co-learning Space (3D MCLS)*, dedicated to collaborative learning allowing students to share 3D models as well as performing blind peer assessment. The system allows a user to store, share, display, and discuss 3D models and allows a teacher to manage a group of students in a flexible way. More specifically, the system can automatically create a thumbnail by computing an optimized view of an uploaded 3D model. It uses tags to organize models into groups according to their attributes or teams in a class for easier access through search. In addition, it can provide blind assignments of peer review and compare the results with self-assessment. We have implemented such a system and conducted a pilot study to obtain a preliminary evaluation on the usability of the system.

***Keywords*—**3D Printing, Collaborative Learning, Peer Assessment, 3D Model Co-learning Space.

## I. Introduction

In recent years, 3D printing technologies have become more mature and accessible to the general public, especially under the trend of maker movement. In addition to making prototyping of a product easier, 3D printing is also widely used in school education to create student art work or teaching aids aiming at facilitating the learning of abstract concepts through concrete object models. Due to the popularity of 3D printing, a vast amount of 3D models have been designed and created by students at various levels of education. However, we have not found any of the current Learning Management Systems (LMS) dedicated to the presentation of 3D models or the learning of 3D modeling. On the other hand, although a few model sharing web sites have been in service for some years, most of the functions on the web sites are not designed to facilitate model sharing and collaborative learning in a specific group.

In this paper, we will report a web site that we have developed to enable easy sharing and collaborative learning of 3D models created in small groups. In addition to the commonly found functions of storing, sharing, searching, and displaying 3D models, the web site, called *3D Model Co-learning Space* (*3D MCLS*), also features 1) automatically generating thumbnail for a best view of a model, 2) using tagging to organize learning groups and activities, and 3) supporting blind peer review and self-assessment comparison. In addition, the system allows a user to put a 3D pointer at a focus location from a chosen specific view before making comments to a model. We have also conducted a preliminary pilot study to evaluate the design and usability of the system.

In the rest of the paper, we will report the work pertaining to research in Section II. The design of the system, including implementation details, will then be introduced in Section III. The experiment designed to evaluate the system and its results will be presented in Section IV. Finally, we will end the paper with conclusions and future research directions.

## II. Related Work

### A. 3D Model Sharing System

Most of the 3D model sharing services are not designed for educational purposes. 3D model is a type of digital content that can be managed in traditional learning management system (LMS). However, since the way to share and view 3D models is more specific, most LMS's do not provide specific functions to support this type of content, neither the associated Learning Content Management Systems (LCMS). Therefore, most web sites that share 3D models are standalone and independent of the existing LMS's. In fact, most of the 3D model sharing services were set up for sharing models created for 3D applications such as computer games or animations. The exceptions for 3D printing are mostly set up by the manufacturers or retailors of 3D printers. For example, My Mini Factory [7] is a web site maintained by the retailor, iMakr that features guaranteed printable 3D models. Thingverse [9] is another popular service, maintained by Makerbot, a 3D printer manufacturer. Most of these web sites supports model sharing, searching, viewing, and commenting to some degree. However, instead of for small group discussions in an educational setting, the target users are the general public who have created good 3D models to share or are trying to find a good model to use.

### B. Collaborative Learning

One of the key features of an innovative service for learning 3D modeling is collaborative learning, especially through peer

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assessment. Previous work has shown that, compared to playing as an audience, peer review can encourage students to participate in learning activities more actively [2] and can be used as a tool of self-reflection in the learning process [8]. Topping has also shown that peer review can be used to improve learning efficiency and quality, and the reliability and efficacy of peer review is at least as high as the assessment by professional teachers [11].

Chi has proposed a classification method for the types of feedbacks in a peer review including corrective, reinforcement, instructive, suggestive [1]. Corrective feedbacks are used to correct the mistakes made by the peers while the reinforcement feedbacks are encouraging positive comments. Instructive feedbacks elaborate on detail directions about how to make improvement while suggestive feedbacks give hints or comments for students to rethink or to remake a decision.

Peer assessment is made online in recent years with the support of learning management systems. Experiments show that online peer assessment can not only allow a student to learn from other peers' comments, but also learn when to make comments to others [12]. The quality of a project and learning outcome can be improved through peer assessment. Another research also has similar findings in improved project quality through peer assessment: suggestive comments and feedbacks are more useful for improving learning than simply rating [6]. Therefore, it is important to encourage students to provide textual comments in peer assessment.

## III. System Design

We have designed a web-based system that allows sharing and learning of 3D models on different operating systems with browsers supporting HTML5 and W3C international standards such as Chrome and Firefox. The system uses WebGL, canvas, and javascript to provide interactive frontend functions to the users and uses PHP and MySQL to access 3D model and user databases.

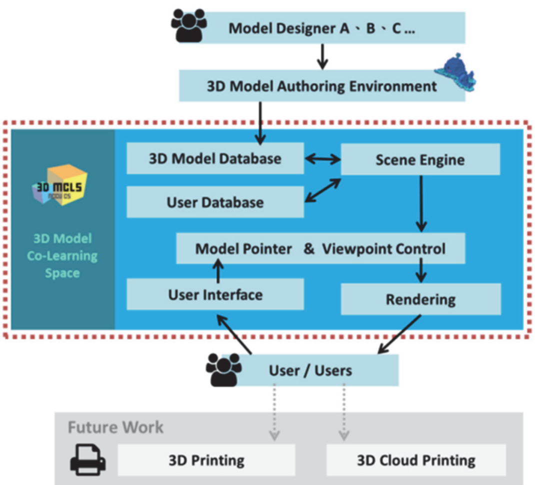


Fig. 1 System architecture

The system architecture is shown in Fig. 1. The modules in the red box with dot lines are the focus of this work. The scene engine is used to display a 3D model in a 3D scene with grid planes on the canvas. A user can manipulate the viewpoints with the common pan, tilt, and zoom functions through a viewpoint controller. Through the model pointer module, a user can add a 3D pointer to a specific location of a model from a selected view when making a comment to the designer of the model.

### A. Design of Model Sharing Functions

3D MCLS provides basic functions for sharing 3D models such as uploading, tagging, displaying, downloading, and discussions. A screen dump of the web page of the system with thumbnails of the uploaded models are shown in Fig. 2. The display thumbnails can be sorted according to the model names, upload times and their popularity such as number of likes, downloads and discussions. The models can also be retrieved through keyword search on name and tag.

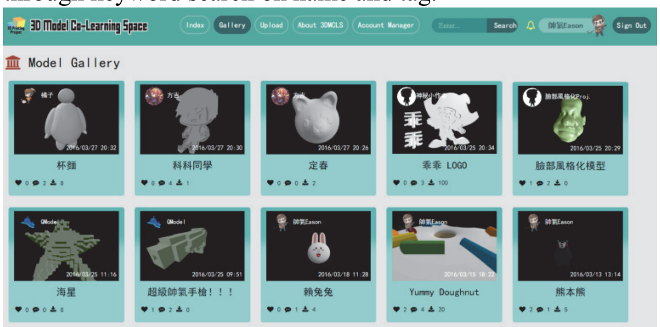


Fig. 2 Model browsing interface

When the thumbnail of a model is selected, a model viewing page will be displayed, as shown in Fig. 3, with detail information about the model such as author, upload time, description, and tags.

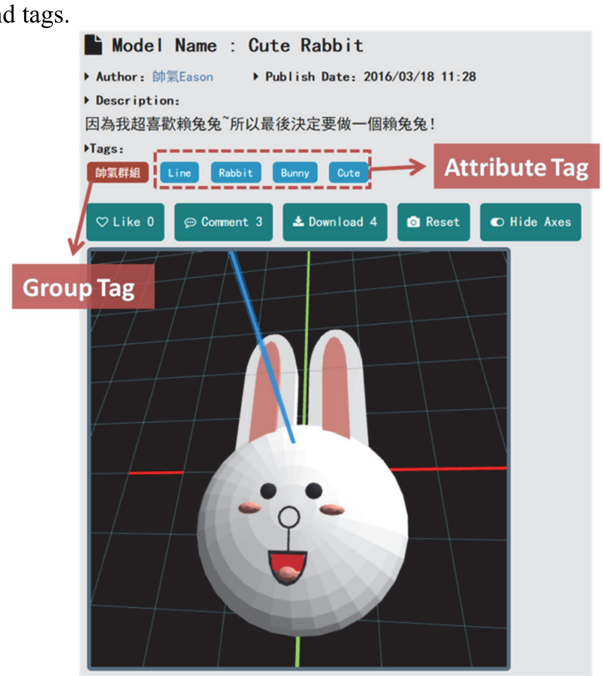


Fig. 3 3D Model display interface

A 3D model can be displayed from a viewpoint automatically selected by the system or its creator. In fact, the thumbnail is created automatically by taking a screen dump of the model from the designated viewpoint when the model is uploaded. In addition to 3D models, the system also supports the upload of an image file that can be used for sketching and discussing a 3D model before it is created. The display widget can automatically switch to the correct display model according to the type of the uploaded file.

### B. *Design of Collaborative Learning Functions*

The system is designed to facilitate collaborative learning about 3D models through peer assessment. Users can leave comments to a 3D model in two ways: general comments to any models accessible in the database and review comments by peer students in a learning group. Anyone can create a learning group and add members into the group although a group is typically managed by the teacher. A group is identified through the use of a specific group tag that a 3D model belongs to. The group tags are special tags (red boxes in Fig. 3) aside from regular attribute tags (cyan boxes in Fig. 3) and define the visibility of a model in a group setting. For example, when clicking on a group tag, a user can see all the models belonging to the group and perform the functions dedicated to peer assessment.

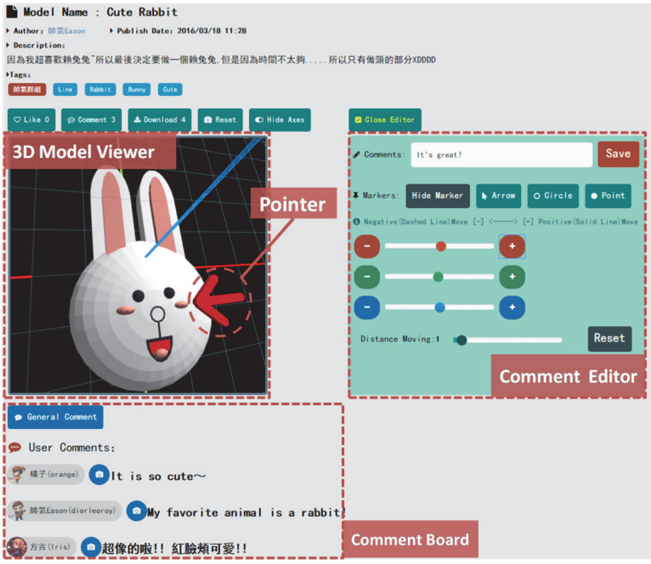


Fig. 4 General comment and model pointer functions

We have designed a special pointing mechanism with comments to improve the clarity and efficacy of peer feedbacks. In the general comment page of a model, a user can choose and position a pointer to a specific location of the model from a selected viewpoint when leaving a comment to the model as shown in Fig. 4. The associated view is restored and synchronized when the comment is selected by another user. If the uploaded file is a sketch image file, the system provides an overlaid scrabble layer allowing a user to draw or type directly on the image as shown in Fig. 5. The data on the layer will be saved together with the model.

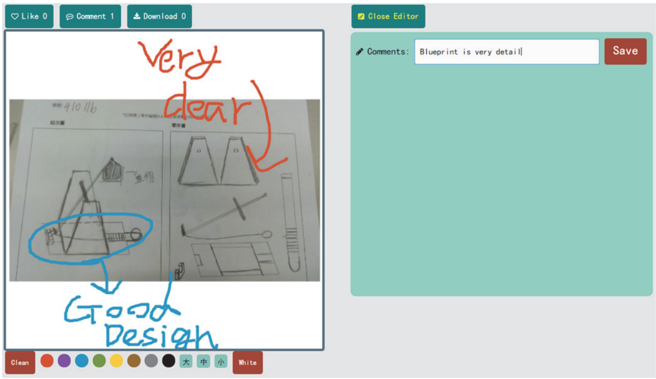


Fig. 5 Overlaid scrabble layer on a sketch image

In addition to the general comment function, we have also designed special functions for peer assessment as shown in Fig. 6. A group manager, usually a teacher, can create a group activity for peer assessment and define the questions to be asked for quantitative feedbacks. The group manager also needs to determine if the assessment includes self-assessment and if it is a blind assessment. If the peer assessment is blind, the manager can ask the system to assign the reviews randomly and automatically by specifying the required number of peer reviews for each work. Not until the blind review session is over, the review comments will be shown anonymously only.

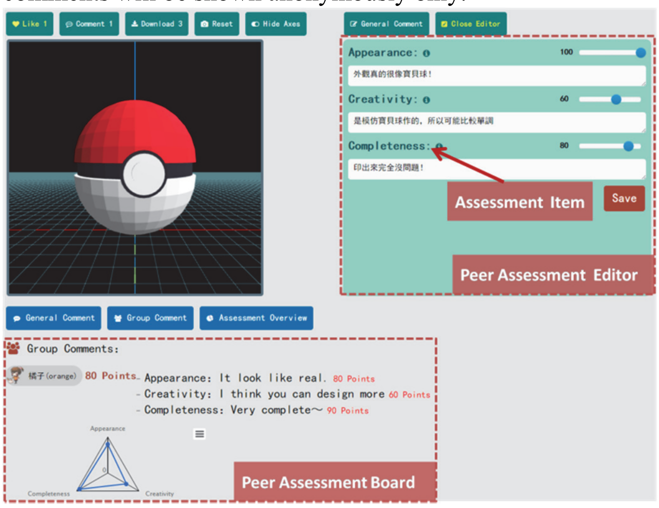


Fig. 6 Peer assessment interface presented to a reviewer

The author of a model can be asked to perform self-assessment. The result can also be compared with the results of peer assessment through a radar chart in the assessment overview page, as shown in Fig. 7. The comments will be presented to the author blindly or unblindly according to the fact that if the peer review is still in session.

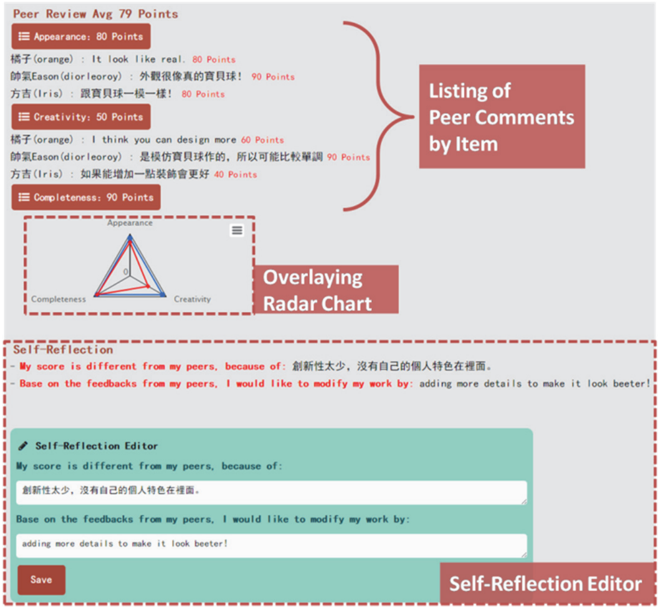


Fig. 7 Self-reflection can be done in the assessment overview page

## IV. Experimental Design and Results

### A. Experimental Design

In order to evaluate if the implementation of the system has met the design goals, we have conducted an experiment to obtain preliminary feedbacks from the users. The subjects participating in the experiment are 19 students from a 3D printing club of a senior high school. All of them have the experience of printing 3D models. The subjects are asked to use the system in five lectures spread out in a duration of 2 months. In the first lecture, the students are given a tutorial about how to use 3D MCLS. Since then, they started to use the 3D model database to browse other people's work and search for inspiring models. In the following lectures, the students learn how to use 3D modeling software to design their own art work. At the end of each lecture, the students are asked to upload their designs to a specific activity (via activity tag) on the 3D MCLS system. The students are also asked to comment on other students' work via the general comment function and the group specific peer assessment functions. The created 3D models at the end will be printed and presented to other members in the school.

### B. Results and Analysis

A survey consisting of 20 questions in the 5-point Likert scale (from 1: strongly disagree to 5: strongly agree) was designed and distributed in the last class to get feedbacks from the users about their experiences in using the 3D MCLS system. Following the questions is a multiple selection session about their favorite functions in the current system and the desirable functions for the future. Then an open question session is arranged at the end for further textual feedbacks. The questions and their average scores are listed in Table I. The questions can be classified into four groups: general functionality (1-4), 3D display functionality (5-11), peer assessment (12-16), and overall evaluation (17-20).

In general, the feedbacks from the users are positive with an average score of all questions at 4.00 (agree), ranging from 3.84 to 4.21. More specifically, in the general functionality group of questions, the users agree that the upload process is easy and fast (4.11), and the tag grouping and coloring seem to be not easy to understand without explicit explanation (3.84). In the 3D display functionality group, the users consider the in-page 3D viewing functions being useful (4.16, 4.21) but the manipulation functions such as zooming and shifting are not as intuitive as they desire (3.84). Since the way we design the zooming and shifting functions with mouse dragging is the same as most 3D viewers, we think the lower scores may mean that the users are still not very familiar with the control in 3D displays. In the peer assessment group of questions, the users consider the design of pointer with a synchronized view can help them understand better the textual comments made by peer reviewers (4.16). However, from a reviewer's point of view, the users think recording a viewpoint together with a comment is as helpful (3.89) probably due to the extra work that needs to be done to take advantage of it. In the overall evaluation group of questions, the average scores are all around 4.0, showing that the users are satisfied with the layout or functions provided by the system.

In the multiple selection session, the users are asked to select the functions that they like most in the current system and list the functions that they would like to expect in the future versions. Most users like the function of being able to display and

TABLE I
Questionnaire and Result

| # | Questions | AVG | STD |
|---|---|---|---|
| 1 | The layout design of the system is clear, and it is easy to find the functions you need. | 4.00 | 0.73 |
| 2 | Tag grouping and coloring are intuitive and easy to understand. | 3.84 | 0.73 |
| 3 | The upload process is simple and fast. | 4.11 | 0.72 |
| 4 | It is helpful for the system to generate a thumbnail automatically from the selected screen dump. | 4.00 | 0.73 |
| 5 | Being able to view and manipulate the 3D model on-line after upload is helpful. | 4.16 | 0.74 |
| 6 | I can grasp the model through the 3D interface. | 4.21 | 0.77 |
| 7 | Rotating the model is smooth and intuitive. | 4.00 | 0.65 |
| 8 | Zooming in and out is smooth and intuitive. | 3.84 | 0.74 |
| 9 | Shifting the model is smooth and intuitive. | 3.84 | 0.59 |
| 10 | Displaying coordinate axes and grid plane help me orient the model. | 3.89 | 0.79 |
| 11 | The reset viewpoint button is useful. | 4.05 | 0.83 |
| 12 | Recording the viewpoint when making a comment is helpful. | 3.89 | 0.64 |
| 13 | Using a pointer to specify the location of focus when making a comment is helpful. | 3.95 | 0.89 |
| 14 | Synchronizing the viewpoint with the reviewer when reading a comment is helpful. | 3.95 | 0.69 |
| 15 | With the location pointer, I can better understand the comments of the reviewers. | 4.16 | 0.74 |
| 16 | From the review comments, I can better understand the focus of different reviewers. | 4.05 | 0.76 |
| 17 | The function layout and arrangement of the system are intuitive. | 4.05 | 0.60 |
| 18 | The operations of the system is smooth. | 4.00 | 0.65 |
| 19 | The functions provided by the system are satisfactory. | 4.00 | 0.73 |
| 20 | I would like to use the system in the future to share and discuss models. | 3.95 | 0.69 |

manipulate the viewpoint to examine the models created by themselves or by their peers in a web page. They also like the group discussion functions including the general comment board or peer assessment board allowing the members in a group to have more focused discussions. Regarding the future desirable functions, most users think the system should allow entering multiple authors to encourage collaborative design. It would also be great if the system can provide cloud printing to a specific printer and provide version control to the uploaded models. In addition, it is also desirable to have replies directly under a specific comment to encourage dialogs between the author and the reviewers.

## V. Conclusion

In addition to the general functions commonly found in a 3D model sharing web site, we have designed a web-based system featuring in-page model viewing, pointer augmented commenting, group and activity tagging for peer assessment, customizable peer review questions and assignments, etc. to create space to support collaborating learning on 3D models. We have also conducted a study to evaluate our system, and the preliminary results show that the functions and usability of the system has met the design goals. Based on the feedbacks by the test users, we will continue to add feature functions to our system such as searching models via sketching or an existing model, providing an API for other applications to upload 3D models into our system, and support cloud printing for selected 3D printers.

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