Learning in Doing: A Model of Design and Assessment for Using New Interaction in Educational Game

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Abstract. To put into practice what has been learned is considered as one of the most important education objectives. In the traditional class, it is difficult for learners to engage in practices since teachers usually convey knowledge and experience by speaking or simple demonstrations, like using slides and videos. This brings obstacles for learners to apply what they have learned to solve real problems. Educational game with the novel input and out technologies is one of the solutions for learners to engage in the learning activities. It can not only effectively encourage learners to learn positively and vividly, promote learning interests and motivation, and enhance the engagement, but also improve their imagination, learning performance and other learning behaviors. This paper first discusses the learning theories related to educational game. Then a literature review is conducted by collecting data on the topics of assessment of educational game with new interaction. Next, we propose a model to guide the design and the evaluation of educational game due to the missing studies. This model underlies an educational game to foster the garbage classification learning with virtual 3D output and natural gesture input using Leap Motion, which is a tracking device of hands and objects. To analyze users' learning behaviors and evaluate their performance and experience, we conduct an evaluation with 22 college learners. Results showed that the use of the natural interaction not only made the learning interesting and fostered the engagement, but also improved the absorption of knowledge in practices. Finally, a discussion of the challenges and future directions is presented.

Keywords: Educational game · Gesture interaction
Learning · Virtual contents · Review

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1 Introduction

Educational game is a game designed for a primary purpose of pedagogy rather than pure entertainment, which could provide learners plenty of opportunities to put into practice what they have learned and to solve real problems. Educational game using novel interfaces and technologies offers rich user experience for learners to engage in the learning activities, encouraging learners to react positively and vividly, promoting learning interests and motivation, and improving their imagination, learning performance as well as other learning behaviors. Educational game has gained many interests from researchers in the field of educational technology and other fields related to this topic. Although educational game supported by new interfaces and technologies provides rich experience and practice opportunities, the design and assessment of the game is lack of guidance. Going a step further, the perspectives of design and assessment of educational game are more based on pedagogical points. This paper revolves around the topic of educational game, the terminology of which varies among researches. To make it clear the base of this paper, we list and describe these terminologies commonly used in the topic of educational game:

(a) *Educational Game*
Educational game has been widely used when mentioning a game with the purpose of enhancement of learning, like in [12,15]. The work [12] derived the pedagogical requirements into three aspects, that is, integration with online education, adaption and assessment. It also discussed general design principles for educational games, including (1) choosing an appropriate genre, (2) adding assessment and adaption to the design, and (3) integration with an online environment.

(b) *Game-based Learning*
Game-based Learning also has been widely used in educational research on game, like in [7,9,14]. In the work [7,14], game-based learning refers to the game enhancing knowledge and skills acquisition and involving the activities of problem solving and competition. Kirriemuir and Mcfarlane [7] proposed and emphasized two key themes on the development of games for education, including "Make Learning Fun and From Fun to Flow" and "Learning through Doing".

(c) *Serious Game*
Serious game with educational objectives is studied by many researchers. Serious game, or called applied game, is a game designed for a primary purpose other than just entertainment [2,10]. The "serious" defines the purposes of the game for education [3], scientific exploration, health care, emergency management, engineering, etc. The point of serious games explicitly emphasizes the additional pedagogical value of fun and competition.

(d) *Other Terminologies*
We also survey and examine the recent literature with regard to educational learning. The following terminologies have been used: design-based learning [6], educational computer games [6], digital game based learning [1], educational gaming [16], e-learning games [5], and educational digital games [12].

This paper focuses on proposing a model taking consideration of both pedagogical and technical perspectives to design and assess educational game. It surveys design guidance, and assessment aspects, and discusses the current issues. To solve the problem as we stated above, we propose a model considering both pedagogy and technical affordance of educational game. Based on the guidance of this model, we implement a game using gestures based interaction of Leap Motion with virtual 3D output and conduct an evaluation to assess the learning from aspects of performance, usability and user experience. Results showed that: (1) it was easy and interesting to learn, perform tasks and play in this educational game. (2) This game provided a good experience for learners and promoted positive emotions, and the game had an appropriate level on challenge. (3) Although there was no difference in performance between pre-test and post-test, the scores were higher in the post-test and it showed that participants experienced a positive emotional state when learning in playing. The use of the natural interaction not only makes the learning interesting and fosters the engagement, but also improves the absorption of knowledge in practices. A final discussion on the challenges and future directions is presented.

2 Design Principles and Assessment of Educational Game

2.1 Design Principles

To inform the design and evaluation of educational games that best meets learner's needs, we propose a model considering both pedagogical context and technologies to achieve the learning benefits. This model provides guidance for the design and the assessment based on our previous studies and the survey. It describes the design guidance, game process and assessment dimensions.

As shown in Fig. 1, the design guidance includes three elements: pedagogical context, features of technologies and the game, roles of the game in learning activities. With regard to pedagogical context, constructivism underlies this model, which proposes that the contexts, activities, and social interactions in the learning environment promote the construction of new knowledge. In the pedagogical context, four key requirements are figured out when the model is employed to guide the design of the application, which are learning objectives, learning styles, learning activities and tasks, as well as motivated learning outcomes. The learning objectives are based on Bloom's taxonomy [4]. The levels of immersion, interactivity and playfulness vary among the various technologies and the game. We also take into account the roles of the game, namely, the game as an application for education purpose, as an instructing tool, and as a learning environment.

Besides, we identify four elements contained in the educational game process: learn, practice (or doing), competition and collaboration.

Finally, in the module of assessment dimensions, we identify three types of measures: performance and usability, cognitive and affective states, as well as the social interaction. The rationale behind the division is based on that the measures are used more commonly in which field. In the cycle of design and assessment, a good performance, usability, positive cognitive states and learning emotions, as well as social interaction are the motivated outputs in the design guidance.

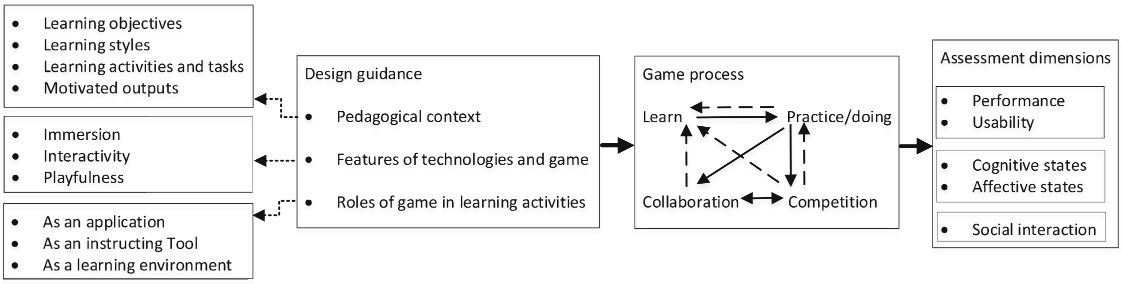

Fig. 1. The model supporting the process from the design to evaluation of educational game.

2.2 Assessment

Assessment of educational game determines how to improve the game and measures whether a game achieves initial objectives. With regard to assessment, various measurement, instruments and approaches are applied to evaluate the game from aspects of performance, cognitive states, affective states and social interaction. As shown in Table 1, we list several researches and the assessment of educational games, including research paper and survey paper. A number of methods have been used to evaluate the educational game. We first categorize the dimensions that are taken into consideration to measure. Then, as shown in Table 2, we classify and list the measures corresponding to the dimension.

Assessment dimensions:

(a) *Performance*
Performance is commonly used to judge the learning outcomes directly, including measures like task completion time, test scores, reaction time, interaction time, and accuracy of interaction.

(b) *Usability*
Usability is the ease of use and learnability of a tool, device or an application. To measure usability, plenty of instruments and scales with different emphasis according to the actual application have been designed and developed. The work [11] proposed an extended TAM model to develop the measurement, including the scales of perceived playfulness, perceived ease of use, perceived usefulness, attitude toward using, behavioral intentions to

Table 1. Current assessment of educational game.

References	Types of research	Measures or Instruments
Law et al. (2016) [9]	Research	1.Performance
		2. Cognitive load, using 9-point Likert-type rating scale with five questions
		3. Engagement (behavior and emotional), using 7-point Likert scale with 12-item instrument
		4.Perceived ability, using 5-point Likert scales
Fu et al. (2008) [5]	Research	1. Concentration
		2. Goal clarity
		3. Feedback
		4. Challenge
		5. Autonomy
		6. Immersion
		7. Social Interaction
		8. Knowledge improvement
O'Brien and Toms (2010) [13]	Survey	1. Aesthetics
		2. Endurability
		3. Felt involvement
		4. Focused attention
		5. Novelty
		6. Perceived usability
Wiebe et al. (2013) [17]	Research	1. Focused attention
		2. Perceived usability
		3. Aesthetics
		4. Satisfaction
All et al. (2015) [1]	Survey	1. Qualitative data
		2. Objective measures of performance
		3. Self-report measures
		4. Similarity pre- and post-tests
		5. Data-analysis techniques

use and actual use. What are required to emphasize is the satisfaction, playfulness and flow. These two items are tested commonly when measuring the usability of an application. Satisfaction means that the user feels satisfied with the interaction and the use of the application. Playfulness represents the state that the user perceives the interaction with the game and finds it enjoyable and interesting. Therefore, the satisfaction and playfulness under the dimension of usability merely refers to the items measuring the interaction other than emotion states. Besides, the flow represents the attention on the interaction with the game, which is placed in the category of usability. However, measuring the user's attention on the learning contents in the game is classified in the category of cognitive states.

(c) *Cognitive states*
Cognitive state is one of the crucial factors determining whether the learning is successful. Cognitive load, engagement, attention are widely used cognitive states in learning.

(d) *Affective states*
In learning, affective processes are intertwined with cognitive processes. When playing games, the intense and diverse of emotions of the user are induced. In the field of Human-Computer Interaction, the user experience is valued increasingly, which focuses on measuring the user's emotions when interacting with an application. In learning, affective dimensions of the learner's experience have increasingly drawn the attentions of researchers and been considered as an essential factor fostering learning. In the study of educational game, affective states are studied including positive emotions (e.g., pleasure and satisfaction), negative emotions (e.g., confusion and frustration), and neutral emotions (e.g., boredom).

(e) *Social interaction*
Social interaction refers to the learner's interactions with peers and teachers. When taking in consideration the social interaction, educational game should provide tasks as a bridge to link socially the learner and other persons involved.

3 From Design to Practice: A Study on Gesture Based Interaction of Leap Motion

In this section, we present a model supporting the process from the design to the evaluation. Based on the guidance of this model, we implement a game using gestures based interaction of Leap Motion with virtual 3D output and conduct an evaluation to assess the learning from aspects of performance, usability and user experience.

Table 2. The methods for measuring four dimensions of learning outcomes and their objectivity.

Dimensions	Measures
Performance	*Performance measures* (e.g., task completion time, scores.)
Usability	*Questionnaire*
	Self-reported measures (e.g., perceived usability, satisfaction and playfulness)
Cognitive states	*Questionnaire*
Affective states	1. Self-reported measures (e.g., arousal and valence, perceived difficulty of materials, devoted metal effort)
	2. Observer's reports
	Physical measures
	1. Behavior detection (e.g., facial expression, gestures and postures, speech and voice, eye tracking and gaze)
	2. Interactions (e.g., typing speed, semantic analysis of assignment)
	Physiological measures
	1. Brain activity measures (e.g., EEG, NIR, fMRI)
	2. Other measures like GSR
Social interaction	Questionnaire: self-reported measures

3.1 Design and Application

We propose an educational game with virtual reality output and natural gesture input using Leap Motion, which is a tracking device of hands and objects. Leap Motion could be used to assist students to explore in the virtual situations using hands. Based on this output and input technique, we design and develop an interactive educational game to foster the garbage classification learning. This game is set up with two sessions, namely the learning and the garbage sorting task. The learning session includes interactive gesture learning and garbage classification knowledge learning. In this scenario, students learn and practice the interactive gestures through sorting the given garbage objects. When the learner is satisfied with mastering the input technique, the interface of knowledge explanation will be presented. Students learn garbage classification knowledge via reading the contents on this interface. The garbage sorting task is designed to evaluate the performance and experience of students as well as make them engaged in this practice.

As shown in Fig. 2, this game process contains three steps: learn, practice and competition, which are realized into knowledge learning module, practice module, and garbage sorting competition module. In the garbage sorting competition module, the participants were asked to sort the garbage as accurately as possible, as well as considering the time consumption (Fig. 3).

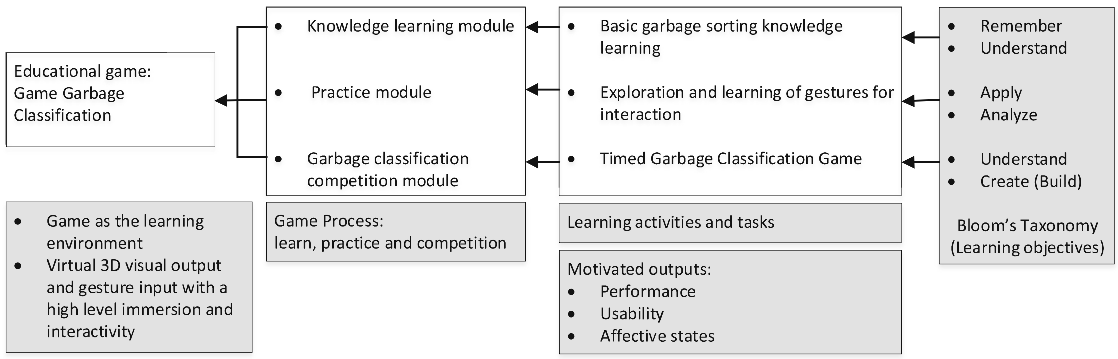

Fig. 2. The design and assessment of Game Garbage Classification based on proposed model.

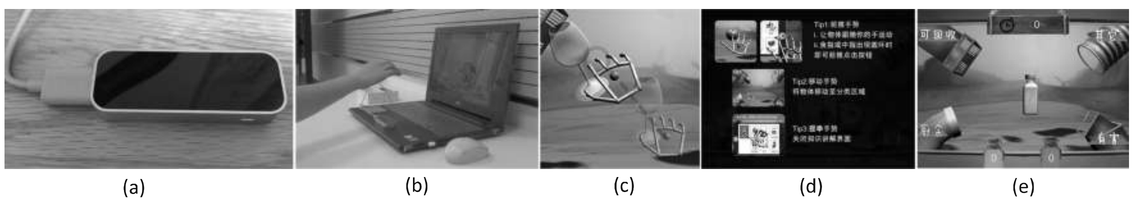

Fig. 3. The configuration, the implementation and the game process of Game Garbage Classification. (a) Leap Motion (b) Using hand to interact (c) Gesture to grasp (d) Learning contents (e) Competition

3.2 Evaluation and Results

To assess users' learning, we conduct an evaluation with 22 college students as participants. We design a questionnaire including usability tests and emotion state measures, the usability questions are based on Technology Acceptance Model (TAM) [11], including perceived usefulness, perceived of ease of use, and perceived playfulness. We employ and adjust the scales to make the questionnaire appropriate for our game application. Our questionnaire is composed of perceived usefulness, ease of learning and perceived playfulness. The emotion state scales are proposed and created based on learning process emotional cycle model [8] by Kort et al. Three main questions have been studies:

(a) In how far do users perceive a good usability when playing this game using gestures? In this question, we explore the users' perceived of ease of use, perceived usefulness and perceive playfulness.
(b) What are their affective states? In this part, we investigate their positive and negative states induced by the game.
(c) Whether there exists significant difference between pre-test performance and post-test performance?

We recruited 22 student participants, including 7 males and 15 females, aged between 19 and 24. The evaluation began with an explanation of the user study. The questionnaire attached to the explanation contained three parts: the background information, the usability test in Likert scale form and the emotion scales. Then all the participants were instructed to learn and use this educational game. A system time logging tool was integrated to record the competition completion time of the game. Finally, participants finished the questionnaire. The following results are presented:

(a) *usability*
In this part, we investigate how users interact with virtual objects in the game using proposed gestures. The gestures include moving, grasping, and selecting objects. We asked participants to respond to the Likert questionnaire items with regard to perceived usefulness. Overall, the median scores were all above 4 with regards to text explanation, images used and navigation, except for the score of evaluating the pointing interaction at the beginning (lower than 3). With regard to ease of learning, we found that the median of all questions were all 4. Playfulness represents a relatively enduring tendency, three dimensions of which were defined by [11], including concentration, curiosity and enjoyment. A perceived playfulness was measured and the median were all 4. Results showed that all participants thought it was not difficult to perform, interact and learn in this game, and the interaction and contents were interesting.
(b) *Affective states*
To measure the emotions induced by the game learning, we employed the emotion sets created by Kort et al. and added one option of "don't have

such emotion" for each emotion set. The axis of emotions include "anxiety-confidence", "boredom-fascination", "frustration-euphoria", "dispirited-encouraged", and "terror-enchantment". Results showed that positive emotions like hopeful, curiosity, interest were generated mostly for participants. A few of participants had negative emotions like indifference, dissatisfied. This indicated that this game provided a good experience for learners and promoted positive emotions, and the game had an appropriate level on challenge.

(c) *Performance*
Shapiro-Wilk tests of observed values (correct rate of performance) showed that data were normally distributed. Therefore, we employed t-test to evaluate if there was a significant difference in performance between the pre-test and the post-test. In the pre-test, participants were asked to sort the garbage in the questionnaire. In the post-test, participants played the game in the competition module. There was no statistically significant difference ($p > 0.05$) between the pre-test and the post-test on the correct rate of performance. This result indicated that the performance of playing garbage sorting when learning in this game and when learning without this game showed no statistically significant difference. The scores were higher in the post-test and it showed that participants experienced a positive emotional state when learning in playing.

3.3 Discussion

(a) Question 1: In how far do users perceive a good usability when playing this game using gestures? In this question, we found that Game Garbage Classification based on proposed model provided a good usability and learning experience for users. It was easy and interesting to learn, perform tasks and play in this educational game.
(b) Question 2: What are their user experience and emotion states? In this part, we investigate their positive affect and negative affect. Results indicated that this game provided a good experience for learners and promoted positive emotions, and the game had an appropriate level on challenge.
(c) Question 3: Whether there exists significant difference between the pre-test performance and the post-test performance? In this part, we found that there was no difference in performance between the pre-test and the post-test. The result indicated that the performance of playing garbage sorting when learning in this game and when learning without this game showed no statistically significant difference. The scores were higher in the post-test and it showed that participants experienced a positive emotional state when learning in playing.

4 Challenges and Future Directions

Game with new input and output technologies are promising in education to meet the pedagogical objectives. In the last decade, educational games have been proved to be successful for fostering learning effectively. Researchers have done plenty of attempts to investigate aspects of educational games. However, challenges still exist when games are applied in education. We concluded four main challenges that the teachers may encounter when generating educational game to foster learning:

(a) *Challenges from the perspective of learning models*
Currently, few studies provide a practical and clear guideline or learning model to inform the design of educational game with new input and output technologies. The levels that the related theories explain how to design an effective game are vague and not clear. With regard to various game applications, the pedagogical basement behind the game and objectives are commonly described insufficiently. Besides, learning models should indicate the integration of educational game and the learning environment, that is, how to integrate the game into conventional class and smart classroom. The roles of the game can be defined either as a supported tool or extended as the learning environment. The organization of learning varies along the variation of the roles of the game. Building an appropriate learning model to inform the design challenges the teachers and instructors, and expects them to well employ learning theories.

(b) *Challenges from assessment of learning process and outcomes*
One of the benefits from educational games is improving the user experience in learning. In contrast to raising the performance of learners, the goal of the game is more on the enhancement of the learning process, and making the learners engage in learning at a high level. In some studies, researchers found that new technologies introduced in learning did not make the learning outcomes significantly different from the performance of learning in a conventional way. Therefore, design and develop effective assessment tools to measure affective states in the learning process in real time is efficient for stakeholders involved in educational game applications. The current assessment technologies supporting real time measures are mainly classified into two ways: physical measures and physiological measures. The former measures include physical features as detection input like facial expression and body gestures. The latter ones include brain activity measures like EEG, NIR and fMRI, and body syndrome detections. These measures are challenging due to the high cost and high complexity to build the related recognition system and to explain the results.

(c) *Challenges from device cost*
Make devices universal in the conventional class or smart classroom would lead to additional cost burden. New technologies and devices introduced in learning like Leap Motion are specific and additional for a class of learners. The Virtual Reality headsets and controllers also cost more than the pads

which are used commonly in some schools deployed in smart rooms. If these interactive devices are expected to be widely used in learning, how to reduce the cost is required to be considered profoundly.

(d) *Challenges of reducing difficulties of teachers in using new technologies to create games*
Interactive educational games are being used at K-12 and higher education institutions. One of challenges that the teachers or instructors may encounter is that the difficulties of using new technologies to create games. To design an appropriate game requires mastering the technology or at least having the ability to be involved in the development team and exacting clear users' needs. To ensure this, the teachers or instructors should be well trained to use the technologies and to solve the technical problems that they may encounter. To go a step further, teachers or instructors should have the ability to adjust the contents in educational game in an actual usage, which may increase the burden of theirs. To balance the cost of time and energy of teachers and their outputs challenges and it requires a practical solution for teachers to follow.

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Technology-Enhanced Teaching and Assessment

Warm Robot Classroom_Using Wearable Technology as a Gateway to Culturally Responsive Teaching

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Abstract. [Warm Robot classroom] is related to answer the question of introduce computational thinking teaching aids and course design by studies robots and wearables with social humanity. The discussion is about how to cultivate students with the rational technology thinking and humanity empathy? The research method includes design and research on cultural response teaching curriculum with the composition of product designers and electronic engineers, planning of teaching contents, and solicitation of teaching and learning of cultural responses from more than five kinds of different cultural backgrounds through the a one semester course. Develop the performances from different cultural groups through 3D printing, laser cutting and digital embroidery creations and assess the applicability of course design.

This course was held with 64 participants (9 different countries, 5 backgrounds). We describe our experience in designing and organizing a wearable course. We will show that (1) Three interactive modules of difficult levels of soft wearable prototypes. (2) The culturally responsive curriculum. (3) The learning outcome of the teaching implementations with interactive toolkits from the final performance.

The result shows that curriculum with different background works together can built students from either side to response to each other.

Keywords: Cultural issues in learning with collaboration technologies
Wearable technology · Smart textiles · Interactive design

1 Introduction

Today's classroom is no longer about analysis, but synthesis. Even though crosscutting and cross-cultural curricula are eagerly awaited for learning, it is even harder to get to an accomplishment. Wearable Technology is related to Interaction, it supposes to be two-way and two-sided; therefore, designing interaction wearable device is to add up both left and right brain apogee at the same time. There are two possibilities to achieve this, to train up a person with both abilities or to work in an integrated manner. Which one is better?

[Warm Robot classroom] includes the learning of wearable technology contents and culturally responsive teaching paradigms by group different cultural and professional

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backgrounds to experience the co-work process and shown the result in a performance on a music show. The course proposal is from "A Warm Robot Classroom_Development and Commercialization of Smart Textiles Interactive Toolkits with Cultural responsive Features" featuring was awarded a grant from the Ministry of Science and Technology (MOST-106-2511-S-130-001 -).

In collaboration with the Department of Electronic Engineering, we launched three innovative programs on workshop teaching and product development and course syllabus. The course is a combination of new media technologies such as interactive LED and laser light projection, interactive air drum music wear that combines sound adapted from the different culture and direction with orientation sensors.

The final presentation, "International Cultural Fusion Wearable Technology Music Workshop presentation" showcased the splendid achievements of new media, science, technology, and intercultural collision. International students are invited to provide international culture to discuss and collaborate with designers and engineers. Through the sound and light effects and music performances, the cultural characteristics of different countries are highlighted.

The program is divided into three parts:

(1) Three different levels of difficulty in teaching cases and interaction packages: Robot, in terms of technology, can be simplified as easy for the study of circuit of how to control the light shine, motor, heat and sound. On the other hands, it can also be developed into clouds data technology and the Internet of Things items. The so-called intelligent world is created by the output behavior and controlled by the input data sensing. The teaching cases of sensor (input) and feedback (output) components are consistent with the teaching content actively and enhance the interest of participation. Wearable technology or Smart Textiles are good materials to express cultural response characteristics and have the concept of science and technology simultaneously. The project is a combination of new media technologies such as interactive LED and laser light projection, interactive music wear that combines sound and direction with body orientation.
(2) Culturally Responsive Teaching: Product designers and an electronic engineers will be team up to plan teaching content and plan. 9 international students are invited to provide international culture to discuss and collaborate with designers and engineers. Participants of different cultural groups will help to interpret their own culture with teammates; designers are responsible for sketches, 3D printing and digital embroidery sewing, etc. Engineers are responsible for the programming and electronic elements. The syllabus evaluations are done in this section.
(3) The stage performance: Through the sound and light effects and music performances, the cultural characteristics of different countries are highlighted. The webpage is the communication platform of showing the smart textiles application cases and teaching materials. And it is also for teachers and learners to share application resources to enhance students' motivation and interest in learning science. She further shared that even though cross-cutting and cross-cultural curricula are eagerly awaited for learning, it is even harder for us to realize what are their accomplishments.

The program, with representatives from Germany, France, Marshall Islands, Tuvalu, Korea, Malaysia, Indonesia, Mongolia and Hong Kong participated in this program activity. Department of Product Design, Electronic Engineering, Information Engineering, Tourism, International College and other students. For two consecutive weekends, teachers and students conducted experiments in the course of "Cultures of International Culture Wearing Technology Music workshop". The results were released and the We Warm Plan completed.

The publication of this achievement passing out the messages that with technology and art allows us to be warmer and closer of the relationship. For more information, please use the following link.

fb.me/wwplan

2 Literature Research

The advent of digital technology in the field of product design is a phenomenon that is part of a global context: the increasing computerization of our societies requires indeed to reconsider their functioning, as well as our ways of living and being in the world. The advent of digital technology in the field of product design is a phenomenon that is part of a global context: the increasing computerization of our societies requires indeed to reconsider their functioning, as well as our ways of living and being in the world. Warm Robot class is a course offered to students in several disciplines. We design and development the teaching aids sponsor by the MOST. Students learned and worked in teams to develop, design, build, and test prototypes with those applications. At the end of the semester students showcase their efforts at the final presentation of a performance show (Fig. 2).

Designers learn and apply the engineering process: defining functional requirements, conceptualization, analysis, identifying risks and countermeasures, selection, and physical prototyping. However Engineer learn from the designers for aesthetics, usability, and the emotional purpose. There are a key issue in-between designers and engineers which is the culture presented by the international students from Germany, France, Marshall Islands, Tuvalu, Korea, Malaysia, Indonesia, Mongolia and Hong Kong.

There are some terms while developing this course and teaching aids that is culturally responsive teaching, wearable technology, and digital performance.

2.1 Culturally Responsive Teaching Paradigms

Culturally responsive teaching (CRT) is defined as using the culturally characteristics, experiences, and perspectives of ethnically diverse students as conduit for teaching (Gay 2002). The student population in Taiwan compare to US remains fairly mono racial but becoming increasingly culturally and linguistically diverse. Many Taiwanese students are lack of experience to cooperate with other cultural students, so attracting international students to participate in the curriculum has become the focus of research. The course was designed according to "the Relevant Themes of Culturally Responsive Teaching"; and offered to students in several disciplines and cultures, hopefully the international outlook of students can be built by this project.

Table 1. Relevant themes of culturally responsive teaching (Aceves and Orosco 2014)

Culturally Responsive Teaching Practices

Relevant Themes of CRT Emerging Evidence-Based	Emerging Evidence-Based CRT Practices	Recommended CRT Approaches and Considerations
Instructional Engagement Culture, Language, and Racial Identity Multicultural Awareness High Expectations Critical Thinking Social Justice	Collaborative Teaching Responsive Feedback Modeling Instructional Scaffolding	Problem-Solving Approach Child-Centered Instruction Assessment Materials

2.2 Wearable Technology

Smart textiles have often reminiscent those can deliver exceptional performance with light, sound, electricity, input and feedback. They were also commonly defined as detection of physiological signals, mood changes, and feedback information to the controller to determine what is the reaction on the textiles.

Smart Textiles are able to sense stimuli from the environment, to react and adapt to them by integration of functionalities in the textile structure. The stimulus as well as the response can have an electrical, thermal, chemical, magnetic or other origin. The Smart Textiles or E-Textiles usually contain both sensing and feedback components. It can sense, test and collect information about people or the environment, such as body temperature or human action. Output through the shining light, temperature changes, image display and other feedback electronic message transmission allow users to feel the situation changes. Smart Textiles, due to the characteristics of sensing and feedback, is different from the general fabric, but also because of the softness is different from electric plastic product. Specific textiles can replace the hard circuit, or show the light and temperature feedback.

The extent of intelligence can be divided in three subgroups:

- Passive smart textiles can only sense the environment, they are sensors;
- Active smart textiles can sense the stimuli from the environment and also react to them, besides the sensor function, they also have an actuator function;
- Finally, very smart textiles have the gift to adapt their behavior to the circumstances (Dadi 2010).

Basically, 5 functions can be distinguished in an intelligent suit, namely: Sensors, Data processing, Actuators, Storage, Communication. (Van Langenhove and Hertleer 2004) When study wearable technology, Smart-Textiles are essential elements to be

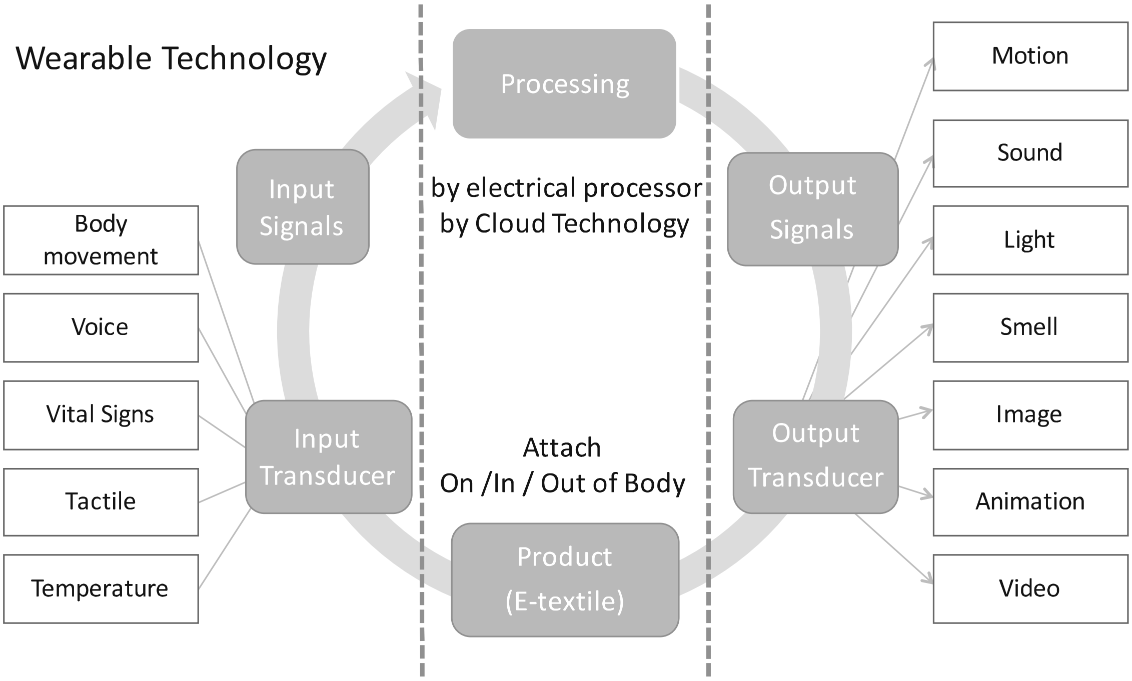


Fig. 1. Process of digital/analog transmission

considered, which incorporates elements of design and fashion and thus it is more gender-neutral than robotics. It is also caters to a much broader range of children's social goals and desire for self-expression (Lau 2009).

Using textiles to design a robot could be an interesting combination of contradictions. We began by surveying the adaptable and accessible smart textiles material in Taiwan to make sure the following production without any doubt which mostly from Taiwan Textile Research Institute (TTRI 2011)and textile industry (Chen 2012). (Chen 2014) Even though those textiles are not defined as "Smart Textiles", but we found that it is quite useful in the idea development as shown in Fig. 1 (Bonato 2005).

2.3 Assessment of Teaching Aids Design

Assessment helps the learner to make more meaningful, dynamic challenging and effective teaching aids. Any consideration must begin with a need analysis, which will help to develop material that enhances all skills.

Another significant aspect of teacher-designed aids is the setting of goals and objectives for the learners. It gives a sense of direction of the course and helps to achieve teaching and learning proficiency. Proper selections of activities will be useful in attaining the purpose of teaching aids.

2.4 Digital Performance

Steve Dixon and Barry Smith, gave the following definition of 'digital performance': "We define the term "digital performance" broadly to include all performance works where computer technologies play a key role rather than a subsidiary one in content, techniques, aesthetics or delivery forms. This includes live theater, dancer, and performance art that have been digitally created or manipulated; robotic and virtual reality performance; installations and theatrical works that use computer sensing/activating equipment or telemeter techniques; and performative works and activities that are accessed through the computer screen" (Dixon and Smith 2007).

In order to practice culturally responsive teaching by introducing wearable technology in design class, we arranged a digital performance stage for students to present what they have learned and their feedback of collaborative teaching for the assessment. Students work in teams to design, build, and test prototypes with real world applications. At the end of the semester students showcase their efforts at the final presentation. At the end student teams display and pitch their inventions and marketability to a panel of judges, invited guest, media, and their peers, while competing for cash prizes. This is an excellent opportunity for sponsors to see how the teams conceptualized their project. The assessments of this performance have two important criteria Technology and Culture.

3 Process

There are three different backgrounds in this projects, designers, engineers, and international students from the other cultures out of Taiwan. The course is built around four main topics, but each part adopts a different perspective on them. Part 1 is an introduction to digital fabrication knowhow. It starts by focusing on 3D printing and laser cutting, and then considers how this affects the group project. Part 2 is comprehensive of the other cultures. In Part 3, the course starts by focusing on learning wearable interaction design, and then considers how these installations can respond to culture. In Part 4, all students undertake a development unit in which they research an aspect of culture in their subject for a digital performance and run the wearable technology show on stage. The course for Part 1 covers:

- 3D printing practice.
- Laser cutting Practice.

Students who have completed Part 1 will join with those international students who are starting in Part 2. Together they have 3 seminars together and work in either subject-specific groups or general groups. The course for Part 3 covers:

- Circuit board Layout with light sensor and LEDs.
- Laser light arts and applications.
- Air Drum with 3-axis accelerometer.

3.1 Course Contents and Pedagogy

There are four types of content: design, culture, wearable technology, and performance. The performance is echoes of the culture and technology learning by designers, engineers, programmers, and the international students.

Table 1 presents the syllabus of our warm robot course, which consists of four parts, with one to two set tasks per level. The set tasks serve, as mini-checkpoints to

Table 2. Warm robot course contents. Totally 36 h

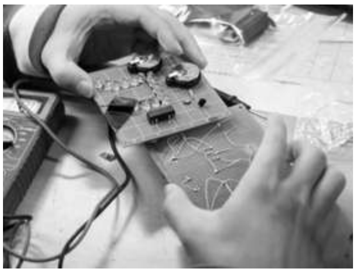
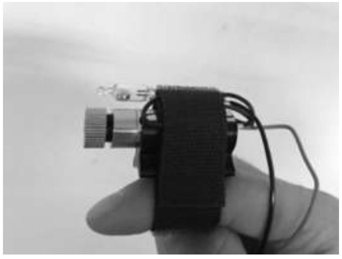
Part 1st - Maker (6 h)	
Contents:	Knowing the skills of making 3D printing and laser cutting prototypes (6 h)
Tasks:	Designers tried out the digital fabrication machine and work out a prototypes Making visual props that enable cultural transmission
Learning outcomes:	Groups work out prototypes of one from 3D printer and one from Laser cutting machine
Part 2nd - Culturally Responsive (6 h)	
Contents:	Knowing the different culture aspects and value (6 h)
Tasks:	International students introduce their culture by PPT Discuss the content for the wearables and performance
Learning outcomes:	Students should give his LED board a look and apply their design on their own clothes Basic electrical knowledge: voltage, conductivity and resistance
Part 3rd - Wearable Technology (18 h)	
Content 1: Electronic Board (3 h)	
Tasks:	Electronic Circuit Theory Circuit Design
Learning outcomes:	Students should give his LED board a look and apply their design on their own clothes Basic electrical knowledge: voltage, conductivity and resistance
Content 2: Laser Light Application (3 h)	
Tasks:	Create simple circuite with Laser Light head, Mercury switch, and light sensors
Learning outcomes:	Make wearable component and design the laser light effect
Content 3: Air Drum Project (12 h)	
Tasks:	Create a complex Air Drum with 3-axis accelerometer
Learning outcomes:	Students should be able to record the voices, write a program that reads in signals from 3-axis accelerometer and send signals to the speakers
Part 4th - Digital performance (6 h)	
Contents:	Run a show following the culture contents with wearable devices
Tasks:	Discuss the entire performance axis and media applications
Learning outcomes:	Knowing how to integrate with different background

make sure that the students have understood the course contents presented in that particular level. The learning outcomes of each level are also listed in the Table 2.

3.2 Prototypes for Idea Development and Teaching Aids

To support this robot course, we designed 3 modules of wearable prototypes. These prototypes were provided to the students as teaching aids to construct wearable technology of electronic devices and the instructions with limited components. This allows the students from having to not worry about technical issues when constructing their circuits, and makes the learning and trial-error process quicker and more enjoyable.

Table 3. Three teaching aids design to support the [warm robot class]

		
1. Electronic Board	2. Laser Light Application	3. Air Drum

These teaching aids prototypes were designed by the following requirements:

1. **Quick and iterative assembly on body:** It should encourage trial-and-error experiments among its users by allowing quick and iterative assembly of a diverse variety of electronic components, including different microprocessors.
2. **Minimum sewing or soldering:** The wearable teaching aids would have to be usable to the users who are beginners without much skill in either sewing or soldering. Therefore, the use of electrical wires, plastic insulation, and solder are avoided or kept at a minimum.
3. **Allow iterative development:** To allow students to learn the basic fundamentals without having to be concerned about material imperfections (such as overly-high resistances), the fabric should support active and hands-on learning and iterative construction and design.

3.3 Collaborative Teaching and Learning

A culminating course proposed by this research was offered to students in several disciplines. Students work in teams to design, build, and test prototypes. At the end of the semester students showcase their efforts at the final presentation.

Warm Robot Class provides students the opportunity to work with open-ended, interdisciplinary challenges. They learn and apply the engineering design process: defining functional requirements, conceptualization, analysis, identifying risks and countermeasures, selection, and physical prototyping.

After Student teams learn from the teaching aids with collaborative teaching, they should have the abilities to design and build working, physical prototypes to validate their presentations. By working in teams they develop leadership skills and group

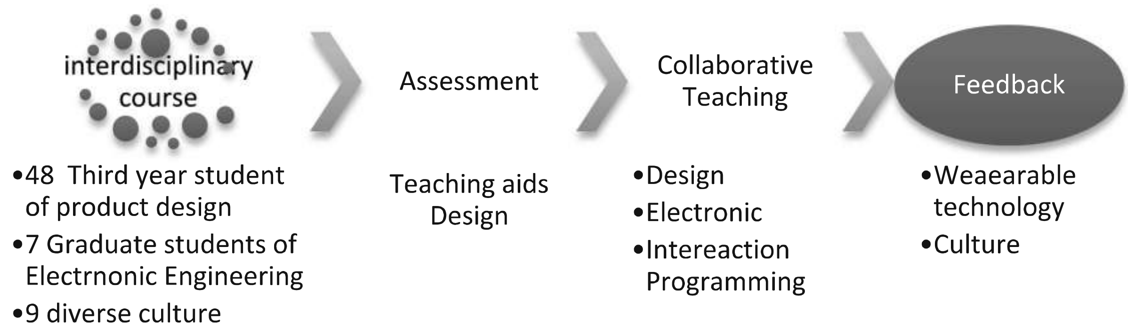


Fig. 2. Syllabus collaborative teaching and learning

dynamics; dealing with scheduling conflicts, meeting weekly deliverables and deadlines; and communication among team members in culturally and linguistic diverse ways.

3.4 Final Presentation Activity_Digital Performance

Proper selections of activities will be useful in attaining the purpose of teaching aids. The final presentation also afforded us the opportunity to see how well the workshop allowed the participants to exercise the creativity. At the end student teams display and perform their wearable digital shows on a prepared stage in front of judges, invited guest, media, and their peers, while competing for cash prizes. This is an excellent opportunity for sponsors to see how the teams conceptualized their project.

There are three collaborative teachers were invited from EE, English teacher from International College, and a movie director, and the director of Tao-Yuan Art Center to be the judges for the performance. Our evaluations were performed using surveys with two measurements. Each measurement has two criteria as shown in Tables 3 and 4.

Table 4. Assessment of the final presentation.

Culture representation: 50%	Wearable technology: 50%
Symbol transformation 25% Teamwork 25%	Technology and media application 25% Visual and sound effect on stage 25%

4 Result

We want to investigate along three angles. First, we wanted to see whether the wearable teaching aids design was inspiring to the students. Second, we wanted to know whether working with diverse culture had helped to simulate the student's imagination? Third, we wanted to know whether working with diverse professions had helped to exercise their creativity and gained some knowledge about technological and programming concepts?

Our evaluations were performed using surveys and feedback from the students. To gauge the difference that every prototype was created, we used 4 post-course surveys after each section of the course and the final presentation to know that if they were inspired by the course and how they felt about the level of difficulty of the tasks.

4.1 Course Outline, Schedule, and Contents

This course was held with 64 participants. 9 different countries from Germany (1), France (1), Marshall Islands (1), Tuvalu (1), Korea (1), Malaysia (1), Indonesia (3), Mongolia (1) and Hong Kong (2). 5 backgrounds from design (41), electronic engineering (7), information management (1), information engineering (5), Tourism (3). In order to perform collaborative teaching, the course was held on two weekends and one evening in December 2017. Syllabus and timetable are as shown in Table 5.

Table 5. Time table of the warm robot class

Date	Time	Contents	Notes
12/2 (Sat.)	9:00–9:30	Registration (30 min)	Camp T-shirt
	09:30–10:30	Keynote_Aqua Chen Digital Fabrication performance	Course outline and introduction
	10:30–12:00	Ice breaking and mixing group 9 teams (4Design,1EE,1-2 Intl.)	Culture comprehensive
	12:00–13:00	Lunch break	
	13:00–14:20	Student presentation, topic 1–4	Q& 10 min/group
	14:20–14:30	Break	
	14:30–15:30	Student presentation, topic 5–9	10 min/group
	15:30–16:00	Group discussing	
Part 1: Visual Symbol			
12/3 (Sun.)	9:00–12:00	Electronic board workshop	Instructed by EE
	12:00–13:00	Lunch break	
	13:00–16:00	Wearable laser applications	Instructed by New Media Artist Mr. Kao
Part 2: Vocal Symbol_ Air Drum			
12/9 (Sat.)	09:00–12:30	Introduction of Arduino, Sensors Knowing the programing methods	Instructed by New Media Artist Mr. Lin
	12:00–13:00	Lunch break	
	13:00–16:00	Figure with the use of sound library. Basic graphics and sound processing, the basic program of drawing	
12/10 (Sun.)	9:00–12:00	Arduino + processing Program Arduino signal into the Processing to control image or sound	

(*continued*)

Table 5. (*continued*)

Date	Time	Contents	Notes
		Lunch break	
	13:00–16:00	Combine air drum electronic components and devices with the installation Combined the program with the actual operation of the rehearsal	
Final Presentation_Digital Performance show			
12/22 (Fri.)	15:00–17:00	Rehearsal	Five Judges: EE Design English Center Art Center Movie Director
	17:00–19:30	Finals by 9 groups (judge and award)	
	19:30–20:00	Closing ceremony	

4.2 Surveys of the Collaborative Course and Wearable Technology Learning

The survey focuses on the interest of if working in an integrated manner in the related subject better? The questionnaire was designed with Likert scale. Student gave feedback right after each Wearable course and the Final performance on stage. Table 6 presents the survey questions. There are approximately 50 respondents include 5 majors, 10 cultures.

Table 6. Survey questionnaire and Summary of Survey Data

Questions for the survey
1. How satisfied you are with the schedule of this course?
2. Your satisfaction with the venue arrangement?
3. Your satisfaction with the content of this course?
4. Your satisfaction with the practicing your profession of this course?
5. Your satisfaction with the lecturer 's teaching skills and ability to express?
6. Your satisfaction with peers of the other culture?
7. Your satisfaction with peers of the other professional background?
8. How satisfied you are with the overall sense of the course?

The result shows that the more difficulty the project is, the satisfaction with peers of the other professionals and or cultures get higher (Figs. 3 and 4).

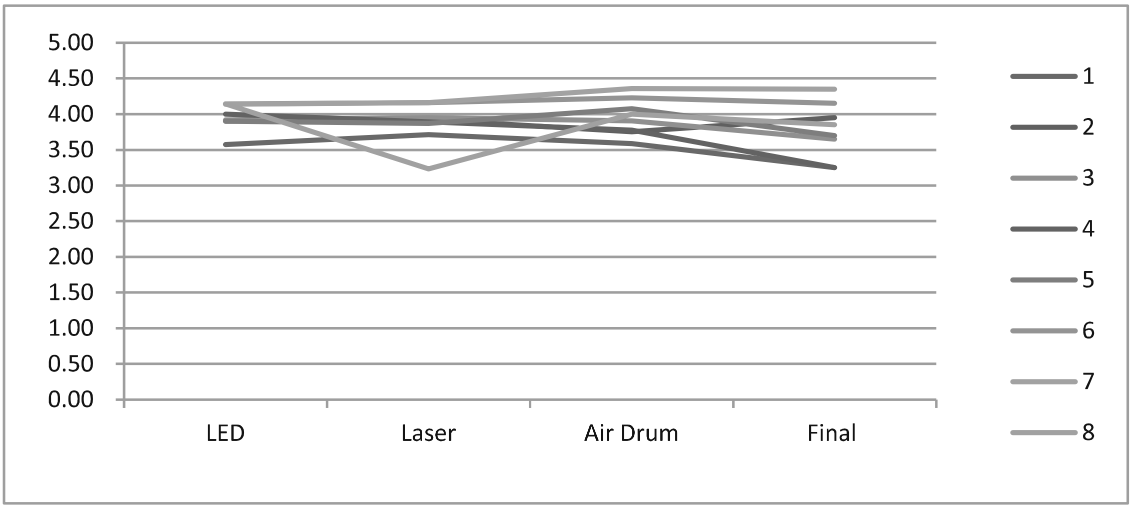


Fig. 3. Variation line chart of 8 questions.

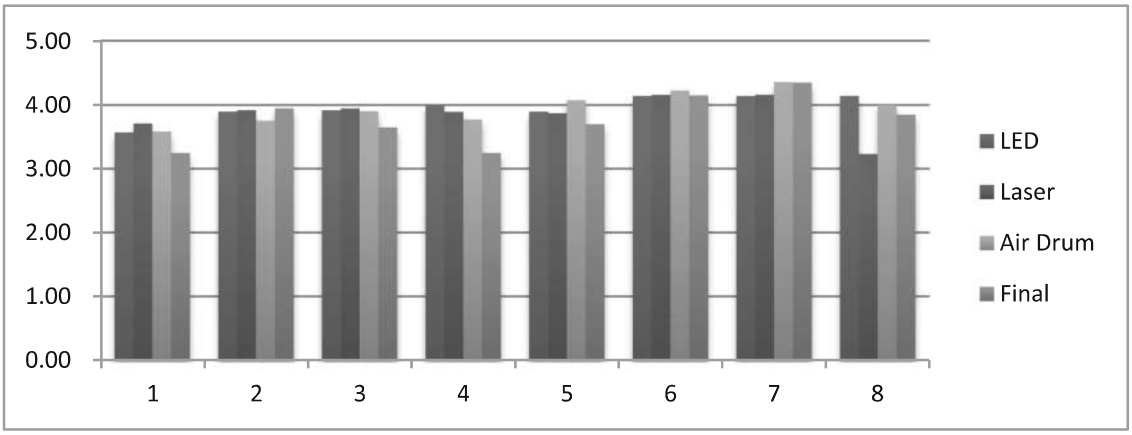


Fig. 4. Variation bar chart of 3 wearable technology learning feedback

5 Conclusion and Discussion

The Warm Robot Class is using composed wearable technology as gateway to design three different teaching aids for a digital performance activity in a course that allow students from different culture and major can cooperate with project base. We want to know if this course design will enhance interest and improve ability of both art and technology learning. From interviews with participants' opinions, we had gotten response as following description.

5.1 Advantage

(1) Teaching Aids Design

This study found that students who engaged in wearable teaching aids design demonstrated significant gains in their ability to diagram a working circuit, as well as significant gains in their understanding of current flow, polarity and connection.

Every wearable's teaching aids for all students is supported by the project plan exploring the specific applications and implications of these key ideas in their curriculum areas.

Students learn from the teaching aids and develop their own props for the final performance (Fig. 5).

Fig. 5. Props developed from the knowledge of the teaching aid design.

(2) Collaborative Learning with Other Major and Culture
We also interviewed by feedback sheets to get the students' feeling as to whether they were inspired by the course and how they felt about the level of difficulty of the tasks. To train up a person with both abilities or to work in an integrated manner in the interaction design related subject, which one is better? The answer is a curriculum with both parts (art oriented right brain and engineering left brain) by collaborative learning, and willing to cooperate with different background will learn the most and achieve the best result.

5.2 Disadvantage

(1) Schedule
Due to the limitation of collaborative teaching from 3 different profession instructors, we have to adjust the schedule and take place the course on two weekends and two weeks later to give final performance on Friday evening. Although Students have high interest and enthusiasm to participate in the final performance but their feedback shown that practice time is not enough. They need more time to do better.

(2) Improvement of Teaching Aids Design
Laser light project is one of the teaching aids. When we want to shown the effect of laser light, the environment condition comes up to be the big issue to prepare. We rent two Frog machine to make the stage look foggy for the better effect to show the LED and Laser light. However, there are 9 groups have to give performance in sequence,

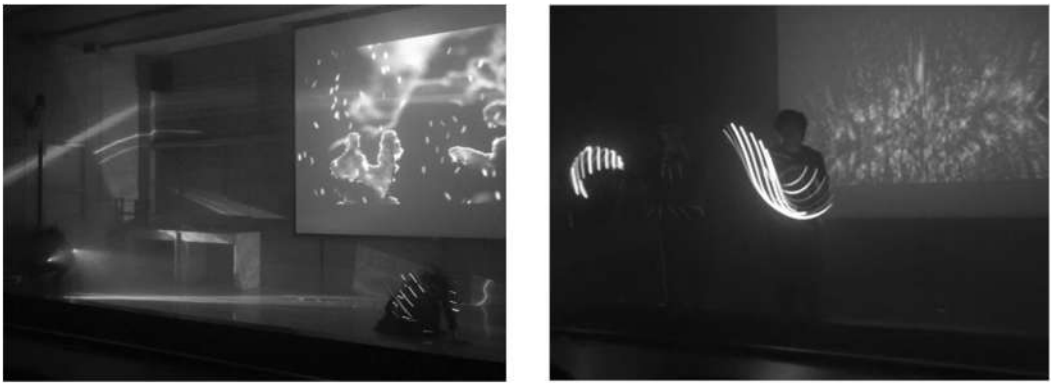


Fig. 6. Laser vs LED

then the laser light that have to adapt the media such as mirror or transparent acrylic will be difficult to move (Fig. 6).

Overall, The class has the following conclusion:

1. Culture bending enhances the learning interest.
2. The outcome of working together with the other professions is better than try do learn the skills and work by oneself.
3. Having the basic knowledge of the other major help build the bridge while communication.

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