The Re-use of Social Resource to Improve Engineering-Education Facilities

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Abstract: In order to provide students with the skills needed to join the semiconductor industry, the M.E. Department of S.T.U.T. has chosen the maintenance techniques of IC packaging facilities to be the starting point of a serial technical training. Financially, it is difficult to purchase brand-new IC packaging facilities to become training equipment. Therefore, the M.E. Department seeks the support of IC packaging companies to donate the facilities phased out from production lines. This petition has gained generous support from ASE Corporation who has donated 10 phased-out production machines to the M.E. Department in two years. Such donations allow the M.E. Department to establish a laboratory to train students the maintenance skills of IC packaging facilities. But some works must be done before converting these machines into educational facilities; e.g., some machines might need minor maintenance, and certain teaching material must be edited for these machines to assist students in learning. This paper will state our experience of converting donated facilities into laboratory equipment, and will point out the problems we face during this process and our solutions. Also this paper will list the effectiveness of using phased-out facilities in technical training, such an evaluation is done, through questionnaires, by students taken the training course.

Keywords: educational facilities, industrial donations

1. Introduction

The continuous growth of semiconductor industries in Taiwan not only becomes the main thrust of Taiwan's booming economy but also creates a lot of working opportunities for the young college students. In order to give students the skills needed in semiconductor industries, the M.E. department of S.T.U.T. organizes a special training program, and has chosen the maintenance techniques of IC packaging facilities to be the starting point. Since maintenance techniques are practical skills, certain laboratory facilities must be established to help students to learn by doing. However, IC packaging facilities are precision equipment and very expensive. Financially, it is difficult to purchase brand-new facilities to become laboratory equipment. In order to resolve such problems, the M.E. Department turns to IC packaging companies for assistance. Since IC packaging companies frequently update their facilities to maintain competitive strength. They also phase some facilities out due to ceasing production of certain products or aging of facilities. Such phased-out facilities may be not useful to the production lines, but they are still functional and contain certain basic IC packaging technology, which make them suitable for training students as the beginners of this particular area. Therefore, the donation of phased-out facilities to schools will create win-win situations in many ways. Firstly, the IC packaging companies have an additional method of assisting the growth of engineering education. Secondly, schools are able to establish laboratories with equipment really used in production lines. Thirdly, students could build up practical experience from industrial-type facilities. That will give them a fast start once they join in production lines. Which means IC packaging companies will be able to recruit a group of new workers that need less training, a payback to their generous donations. Finally, the re-use of phased-out facilities is to make good use of social resource. Instead of turning into chunks of rotten metal or dismantling into pieces, these facilities become valuable educational equipment.

The concept of re-using phased-out facilities has gained support from Advanced Semiconductor Engineering Corporation, the largest IC packaging company in Taiwan. ASE has donated 10 phased-out production machines, valued about 7 millions NT dollars, to the M.E. Department in two years. Such generous donations allowed the M.E. Department to establish a laboratory to train students the maintenance skills of IC packaging facilities. But some works must be done before converting these machines into educational facilities. For example, school laboratory provides different electricity voltages from that used in production lines, so the power circuits of some machines require rewiring. Also some machines might need minor maintenance due to the damage caused by transportation or aging of few components. Besides, certain teaching material must be edited for these machines to assist students in learning. This paper will state our experience of converting donated facilities into laboratory equipment, and will point out the problems we face during this process and our solutions. Also this paper will list the effectiveness of using phased-out facilities in technical training, such an evaluation is done, through questionnaires, by students taken the training course.

2. Approaches

The 10 production machines donated by ASE are listed in Table 1. These donations arrived at the M.E. Department in two lots within two years. The first lot is the first three items in Table 1, and the rest are the second lot. Although these 10 production machines have different ages, there are some common problems in converting them into educational equipment: (1) 9 of the 10 machines do not have operational or maintenance manuals remained after serving a period of time in production lines. (2) These machines used 440V 3ϕ electric power in the production lines, but school laboratory only provides 220V 3ϕ electric power. (3) The power circuits of these machines needed to be rewired to fit the electric power of school laboratory. (4) Since these machines come with no documents, their power circuits need to be traced and redrawn before rewiring. (5) Some of the machines use 3ϕ induction motors to create punching forces; the change of power voltages also affects the junction method of these motors to the power lines. (6) The donated machines are automatic; they need working objects to carry out their functions. However, IC working pieces, even the dummies, are not easy to obtain. Therefore, the control programs of these machines must be rewritten so that these machines could run simulation cycles without working pieces. (7) Most of these machines have PLC as the controllers. Reprogramming these controllers must know the I/O points and the corresponding mechatronic components beforehand. Since no documents are available about these machines, the I/O point data must be rebuilt. (8) The simulation programs must follow the working logic of the original programs, which means that the simulation programs must come after well studies of the original programs. (9) Some components, mostly sensors, are damaged due to aging or transportation; they must be replaced.

Table 1: 10 production machines donated by ASE

No.	Brand: Function
1	PASCON: Trimming system
2	IDEC: Marking system
3	C-SUN: U.V. driver
4	GPM: Dejunk/Trimming system
5	GPM: Forming/Singulation system
6	ASM: Deflash/Trimming system
7	ASM: Trimming system
8	TOWA: Trimming/Forming system
9	GTC: Autoloader system
10	AIS: Engraving system

Apparently, the above problems must be solved first before turning these machines into educational facilities. Since solving the above problems itself is a process of training maintenance skills, it is included in a special project that puts training of maintenance skills into two different stages. The first stage lets students execute the process of converting the donated machines into laboratory equipment. The second stage is to use the results of the first stage as course material to teach students. This special project has been conducted for two years for both lots of donations, and is founded by the National Science Council (NSC) of ROC during the second year, project No.: NSC 88-2511-S-218-001.

Chronologically, the first stage of training takes place at the spring semester and summer break, and the second stage follows up in the coming fall semester. In the first stage, students participating in the training project are divided into teams; each team has three students and is in charge of a donated machine. During the spring semester, all participant students meet regularly three hours per week to learn the elementary mechatronic techniques, besides the regular meeting each team could use its own free time to strengthen the learned skills. During the summer break, the participant students are away from course burdens and have learned certain elementary mechatronic skills. They concentrate on converting the donated machines into educational facilities by solving the nine problems mentioned above, and also rebuilding maintenance manuals for these machines. Now, the outcomes of first stage become the teaching material and equipment for the skill training of the second stage. In the second stage, the training project opens a course to limited number of students. The content of the course is to teach students the maintenance skills of IC packaging facilities.

One particular point should be mentioned that the students participating in the first stage of training must take the training course given in the second stage. There are several reasons of doing so. Firstly, in the first stage each team further divides its jobs between team members based on one's interest or fluency in certain skills, e.g., some students are good at PLC programming, others like to learn how to trace power circuits and do rewiring. Consequently, some of them only learn the skills within the scope of their assignments, and still need additional training to broaden their skills. Secondly, the participants of the fist stage become valuable teaching assistants to the training course in the second stage. Therefore, their joining in the course will share the load of teaching practical skills to a group of students in limited time and facilities. In order to learn the efficacy of the training project, students participating in the training project, in either stage, are given questionnaires to evaluate their improvement in certain mechatronic techniques frequently used in facility maintenance.

3. Evaluations

The training project contains two different stages. Each stage has a particular questionnaire to evaluate its performance. The questionnaires basically contain two sets of questions. The first set asks the participant students to choose a ranking value from a set of numbers to represent their self-examination on each particular question. The second set asks students to give short narration about their opinions on certain issues. The ways of taking questionnaires are different in both stages. The first stage gives questionnaires at the end of training. The second stage gives questionnaires twice, one at the beginning and the other at the end of the training course. Therefore a comparison of both results will show the performance of the second-stage training.

Due to the lack of experience, the first stage evaluation is conducted only on the second year of the training project. But the second stage has evaluations on both years of the training project. Table 2 lists the questions asking students to rank their evaluation or degree of consensus after the first stage of training. The way of ranking is to choose a value between 1 and 5 to represent a self-evaluation in five ranks. A higher value means a better result. It should be noted that only 9 students participate in the first stage of training. So the ranking values are averaged over 9 students in Table 2. It could be seen form Table 2 that students have a very high consensus about using industrial facilities to improve their technical skills. They also indicate strong interests of joining in both IC packaging and automation industries. About the improvement of technical skills, students choose values from 2.4 to 3.9 to represent their self-examination. The lowest value 2.4 is about the capacity of designing automatic machines. Since, to most of the students, it is the first time that they work on a real production machine. It is not surprised that they feel not ready to design automatic machines even after the first stage of training. The rest of the values are above the middle rank, value 3 in a range from 1 to 5, some of them are close to value 4. It could be interpreted as that students have positive senses about their improvement after the training.

Table 2. Self-evaluation on the improvement of technical skills after the first stage of training (ranking value: max=5, min=1)

Questions[1]	Average ranking value[2]
(1) Capability of tracing and rewiring the power circuits of production machines	3.8
(2) Capability of decoding and rewriting PLC control programs	3.6
(3) Knowledge about IC-package manufacturing process	3.9
(4) Hookup and usage of 3ϕ induction motors	3.0
(5) Maintenance skills of production machines	3.6
(6) Usage of man-machine interface and programming skills	3.6
(7) Capacity of rebuilding maintenance manuals for production machines	3.7
(8) Mechatronic skills and their applications	3.8
(9) Design the motion procedure of production machines	3.2
(10) Knowledge about punching molds	3.1
(11) Using CCD and image processor in image grabbing and processing	3.4
(12) Capacity of designing automatic machines	2.4
(13) The interest of joining IC packaging industry	4.7
(14) The interest of joining automation industry	4.3
(15) The consensus of using industrial facilities to improve technical skills	4.8
Note 1: Questions 1~12 are regarding technical skills; 13~15 ask students the degree of consensus about that particular issue. Note 2: The ranking values are averaged over 9 effective questionnaires.	

In the first stage questionnaires, students also write down their opinions to certain questions. By using (x/y) to indicate that x out of total y students have the same opinions, the questions and the mostly mentioned opinions are listed as followings. (a) The difficult parts of the first stage training are: power wiring (7/9), mechatronic skills (6/9), PLC control program (3/9). (b) The merits of this training are: learning mechatronic techniques (5/9), improving PLC programming skills (5/9), learning mechanism designs (4/9), knowing IC packaging process (4/9), learning the skills of wiring power circuits (3/9). (c) Suggestions to the next participant students are: strengthening PLC and mechatronic backgrounds (5/9). Apparently, students feel that mechatronic and PLC programming techniques are important in learning the maintenance skills. They not only gain improvements from the training but also wish their followers seeing such needs.

The evaluations of the second-stage training are conducted before and after the course. Both results are compared to see the improvement after taking the training course. In the questionnaires, students mark down their judgement on the degree of familiarity with certain mechatronic components or techniques. Table 3 lists the results taken at both years. The results of before and after course are cited, as well as the amount of improvements.

Table 3. Self-evaluation of the familiarity with mechatronic components or technique before and after taking the second-stage training course (ranking value: max=5, min=1)

Mechatronic components or techniques	Fist year[1]			Second year[2]		
	Before	After	Imp. [3]	Before	After	Imp. [3]
(1) Magnetic contactors	2.0	3.6	1.6	2.2	3.5	1.3
(2) No fuse breakers	2.4	3.9	1.6	2.7	3.7	1.0
(3) Thermal relays	1.8	3.5	1.7	2.5	3.5	1.0
(4) Counters	2.8	3.7	0.9	2.8	3.6	0.8
(5) Timers	3.1	3.8	0.7	2.8	4.0	1.3
(6) Relays	2.9	4.0	1.1	3.1	4.2	1.0
(7) Photo sensors	2.5	3.4	1.0	2.6	4.1	1.5
(8) Proximity sensors	2.1	3.1	1.0	2.8	3.9	1.2
(9) Reed sensors	2.2	3.2	1.0	2.6	4.2	1.5
(10) Limit switches	2.9	3.8	1.0	3.0	4.0	1.1
(11) Selective switches	2.5	3.5	1.0	2.5	4.0	1.4
(12) Push button switches	3.3	4.0	0.7	3.2	4.2	0.9
(13) Indicator lamps	3.0	4.1	1.1	3.1	4.2	1.1
(14) Transformers	2.5	3.4	1.0	2.5	3.2	0.7
(15) Stepping motors[4]	2.1	3.2	1.1	2.3	2.5	0.2
(16) 3ϕ induction motors	1.8	2.8	1.1	2.2	2.7	0.5
(17) DC servo motors[4]	2.0	3.0	1.0	1.9	2.5	0.5
(18) AC servo motors[4]	1.8	2.9	1.0	1.8	2.3	0.6
(19) Solenoid valves	2.3	3.2	0.9	3.0	3.8	0.9
(20) Man-machine interface[4]	1.9	3.5	1.7	2.0	2.5	0.5
(21) Design of Man-machine interface programs[4]	1.7	3.7	2.0	1.8	2.4	0.5
(22) PLC programming techniques	3.1	3.3	0.2	2.8	3.4	0.6
(23) PLC hookup	2.2	3.3	1.1	2.0	3.1	1.1
(24) Multi-meters	3.2	3.7	0.4	2.8	3.9	1.1
(25) Solid state relays	1.7	3.2	1.5	2.2	3.4	1.2
(26) Encoders[3]	1.7	2.4	0.7	1.4	1.8	0.4
Total average	2.35	3.42	1.07	2.5	3.4	0.9
Total average (without * items)				2.67	3.73	1.06

1: 46 students take the first year course, among them 41 questionnaires are effective.
2: 30 students take the second year course, among them 26 questionnaires are effective.
3. Improvement = (after-before)
4: These items were not yet covered in the second year training course while taking the evaluation. These items were left as the content of consecutive course given in the following semester.

According to Table 3, the total average shows that the first-year students gain improvement about 1.07. Since numbers 1 to 5 represent five ranks, an improvement about 1.07 means moving up a rank, i.e., from a rank below middle (2.35) to above middle (3.42). Having the first-year experience, the training course is extended to two semesters at the second year. Therefore, during the moment of taking the second-year evaluation some items listed in the Table 3 are not covered yet and are left as the course content given at the next semester. By excluding these items from the second-year total average, Table 3 shows a 1.06 improvement of the second-year training, an increment from a value below middle rank, 2.67, to above middle rank, 3.73. Such results are very similar to that of the first year. However, the second year average is about 0.3 higher than that of the first year in both before and after taking the course. Also more items in Table 3 have values above 4.0 after taking the training at the second year. Which could be an indication that students have better technical skills over years.

4. Summary

Most of the students taking the training course feel that the most effective way of learning is by doing, (37/41) in the first year and (24/26) in the second year. This feeling meets the goal of using industrial facilities to train student maintenance skills. From the questionnaires listed above, students joining in the training program have gained improvement on mechatronic skills that are essential to facility maintenance. The accomplishment of this training program relies on several factors. First of all is the generous donation from ASE, whose continuous assistance to the engineering education benefits many universities and engineering students. Another factor is the devotion of students taking the first stage training. These students spend, in average, about 38.1 hours per week during summer break to convert the donated machines into educational equipment and rebuild the maintenance manuals. Also the grant from NSC is crucial to the supplements of mechatronic components needed in the maintenance of the donated machines. Nevertheless, there are some problems remained unsolved. One of them is how to convert the techniques contained in an automatic system like industrial machine into a systematic teaching material. Another problem is how to teach student to read and understand the PLC programs of industrial machines, which are very lengthy and involve a large number of I/O points. Searching answers to these problems is the momentum keeping the training program moving toward a more effective region.