Corporate Education for Manufacturing (Semiconductors) - Creation of a training system and technical textbook -

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Artner Co., Ltd. is currently dependant on a variety of outsourcing systems that have been implemented with a high degree of technical assistance for the completion of projects. In large scale integration (LSI) design and the development of electrical and electronic design, which is one of the outsourcing fields for Artner Co., Ltd., engineers for semiconductor technology are responsible for increasing the proportion of electronic circuit design. The technical staffing services industry has been constantly increasing the number of engineers working in semiconductor technology. In order to more efficiently impart to young recruits and engineers working in semiconductor technology the knowledge that is required to match customer needs, a training curriculum was developed and a technical textbook titled "A way of thinking of practical design techniques—Chapter on semiconductors" was compiled. Their introduction resulted in reduced training time for semiconductor field assignments, an improvement in the efficiency of training, and an increase in the level of training content.

Introduction

Artner Co., Ltd. carries out the business of providing technical assistance using a variety of outsourcing systems in three areas—mechanical design development, electrical and electronic design development, and software development. We dispatch engineers to the technical department of a customer and offer an engineer dispatch service that provides technology in a working form to the company [(1)].

The engineer dispatch service uses students who studied a specific area of engineering systems at university or other institute of higher learning as regular employees, and develops human resources who can meet customer needs using our proprietary employee-education system.

In this corporate structure, it is new employees who are responsible for a great portion of the growth of our company, and a unique feature of our company that sets us apart from other companies in the same industry is how we educate, in a comparatively short period of time, young people who have just graduated from school and entered society, how we assign them to work closely with customer needs, and how this leads to customer satisfaction and a favorable customer impression.

In recent years, large scale integration (LSI) of electronic devices has made rapid progresses in the electrical and electronic design development field, and the percentage of semiconductor development designers that are responsible for electronic circuit design is increasing. Therefore there are customer needs in this field, and we have constantly increased the number of engineers for semiconductor technology in the technical staffing services industry. In this paper, we report on a training curriculum for the semiconductor field and a technical textbook titled "A way of thinking of practical design techniques—Chapter on semiconductors" produced especially for young semiconductor development designers and new employees. The goal is to help them learn, as efficiently as possible, the knowledge necessary to match customer needs. After we developed the materials, we conducted a questionnaire survey to see how well we had met that aim, and in this report we describe the evaluation of this technical textbook and its background.

Outline of engineer dispatch service business

Figure 1 shows a schematic of the engineer dispatch service business. A dispatch agency signs a worker dispatch contract with a customer (dispatch destination) and dispatches engineers who are regular employees of the dispatch agency and forms an instructional relationship between the dispatch destination and the dispatch engineers. Therefore, as the dispatch destination is not liable for the employment, it saves on expenses (of social insurance,

etc.) and the time required to conduct such procedures.

In order that new employees who have recently graduated from school and have just came out into society obtain customer satisfaction, a training system that enables a dispatch agency to educate new employees in as short a period of time as possible and increase the level of engineers is important. The next section describes the training system that has been developed.

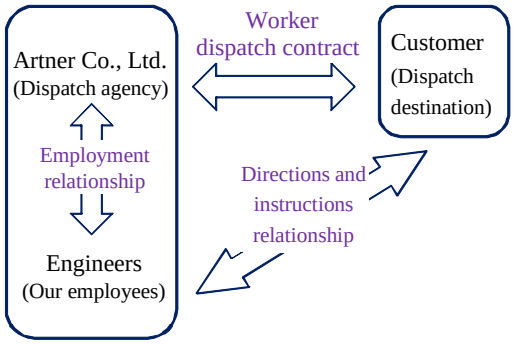

Figure 1. Schematic of Engineer Dispatch Service Business.

Training system

<3.1> Overview of training system

Figure 2 shows an overview of the training system from entrance into a company to assignment. This training system is a flowchart common to the machinery, electrical and electronic, and software fields, and it is developed into a theme that continues to provide state-of-the-art technology software to customers by improving individual competence such as technical competence, business knowledge, management techniques and human power by means of our track record of many years. The main training phase is described below.

1. General training

   As the first step of becoming part of the workforce, new employees learn business manners, workforce consciousness and general knowledge about our company.

2. Basic training

   New employees learn the basic knowledge necessary for design and the basics of design and practice.

3. Application training

   New employees are given specific themes closely related to the customer's site, and master practical skills while experiencing actual design processes, including how to contact design procedures and information sources. New employees learn through experience such as presentation and information sharing.

4. Assignment

   Engineers as determined by a customer are also assigned to a technology group called "Design Jobs" at the same time they engage in actual business. Design Jobs is a special section that provides technology and services, and is an organization on market strategy that responds to customers with technical skills appropriate to that segment. Engineers assigned to this section begin to improve their skills for the design jobs to which they are assigned.

5. Technical Training Subcommittee

   The Technical Training Subcommittee is a workshop held by engineers who work for customers. They conduct training for units of the group in which themed useful technology in the field and high-needs products are taught.

<3.2> Electric and electronic course training for new employees

Figure 3 shows the implementation content in the electric and electronic course training for new employees.

The training begins with an ability assessment test conducted to ascertain individual skills. Next follows 10 field training lectures: electric theory, electronic components, discrete semiconductors, digital circuit, measurements, printed circuit boards, C language, microcomputers, analog circuits and noise; and

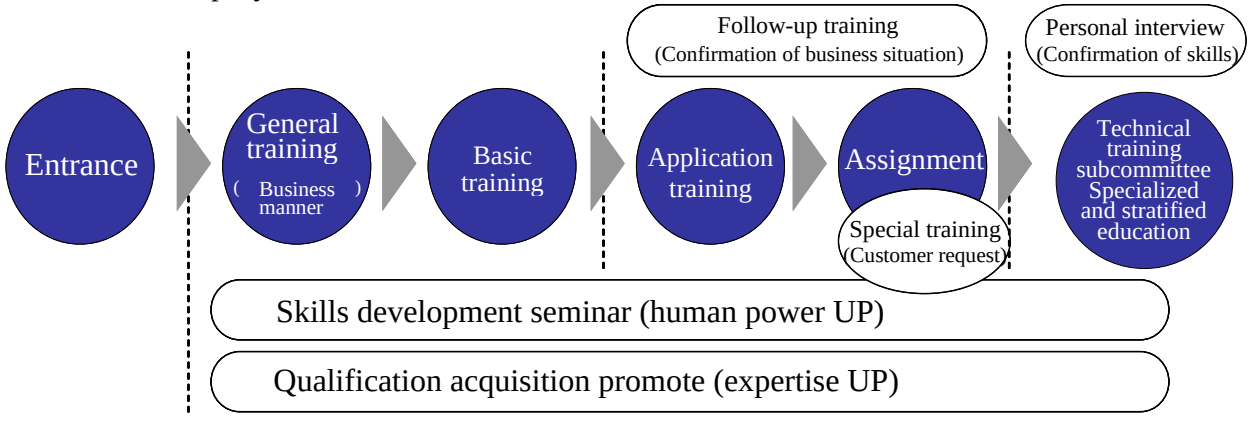

Figure 2. Overview of Training System.

manufacture training in four subjects: RC transient response, chip component soldering, counter circuits, and oscillation circuits. The degree of learning is checked by a basic training final examination, and successful candidates go on to application training.

In application training, through working on a design and manufacturing subject (manufacturing of a simple digital multimeter), trainees enhance their work abilities, including reporting, contacting and consulting. When they complete all subjects, an application training final examination is taken, and the new employee training is completed.

The main points of training are assuming business dealings for various customers, absorbing a wide range of miscellaneous knowledge, improving work skills, improving problem-solving skills, and ensuring awareness of the delivery date. Our final goal is the development of human resources who strive tenaciously to never give up in anything and who can solve problems.

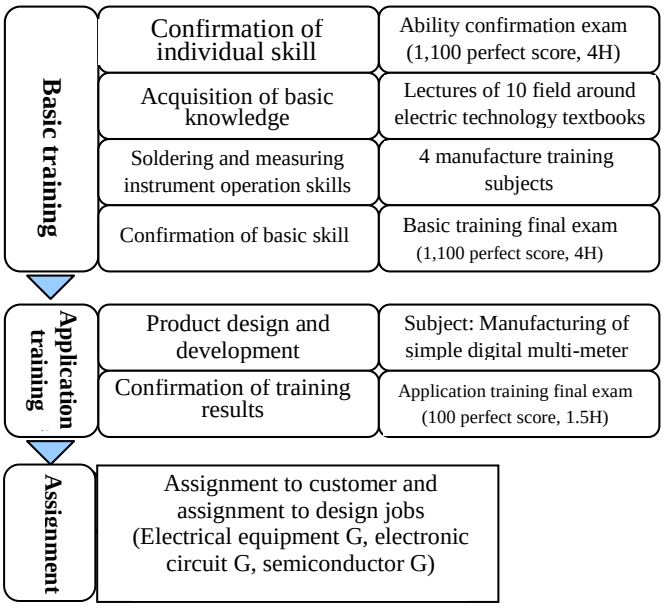

Figure 3. ***Electric and Electronic Course Training for New Employees****.*

<3.3> Changes in customer needs

To meet customer needs as a company, we need to constantly improve customer satisfaction, which will ensure future growth. As the manufacturing site is constantly changing—including the technology, environment and market—it is important to grasp the changes in customer needs when developing a training system. Therefore, we also periodically revise design jobs to match changes in customer needs.

In Sec. 3.1, we said that engineers as determined by a customer are assigned to an engineering group that is segmented by design jobs; however, Figure 4 segments the technical business content for engineers of the customer by age group and shows the transition of design jobs. Thus, it is possible to view the changes in customer needs at each age.

Figure 5 shows the number of engineers divided by Design Jobs in the electrical and electronic course in 2009. The assignment of Design Jobs has been mainstream in electronic circuit groups for many years, and it also is in the new employee training curriculum for the electrical and electronic course, and it assumes assignment to electronic circuit groups. In the semiconductor business, we have attempted to increase the number of engineers every year since we assigned engineers for the first time in 2003. As a result, we reviewed Design Jobs in 2006 and established a semiconductor group. Requests for electronic equipment show a tendency toward miniaturization, high functionality, low power consumption and cost reduction, reflecting today's situation in which customers integrate complex electronic circuits into LSI chips to meet user needs.

Figure 6 shows the changes in the number of engineers in the semiconductor group, and Figure 7 shows the ratios of business fields for the same engineers.

In fiscal 2009, the number of engineers was reduced due to the influence of the Great Recession, which began with the Lehman Brothers Collapse. However, we achieved an increase in the number of engineers of 20% per annum until fiscal 2008—including fiscal 2006, or before we established the semiconductor group. In addition, the design verification business accounted for more than half of the business field, followed by layout design, evaluation work and process development follow and design work, which are the majority.

As of the end of January 2014, the number of engineers divided by Design Jobs in Figure 5 had changed 93 people in "electric equipment", 149 people in "electronic circuit", 7 people in "semiconductor", and the number of "semiconductor" had declined due to the collapse of Lehman Brothers.

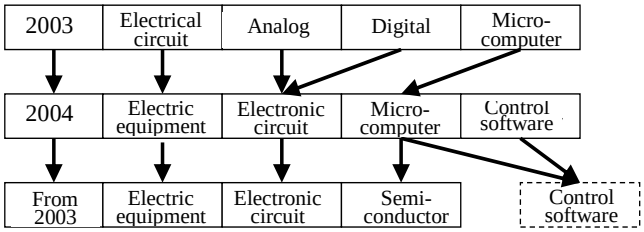

Figure 4. Transition of Design Occupational Category.

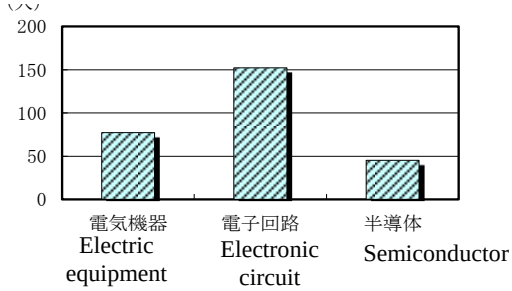

Figure 5. Number of Engineers According to Design Occupational Category.

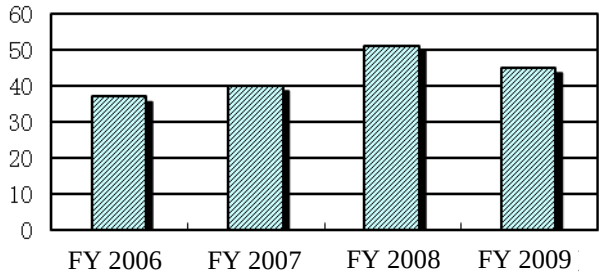

Figure 6. Transition of Number of Engineers that Belong to the Semiconductor Group.

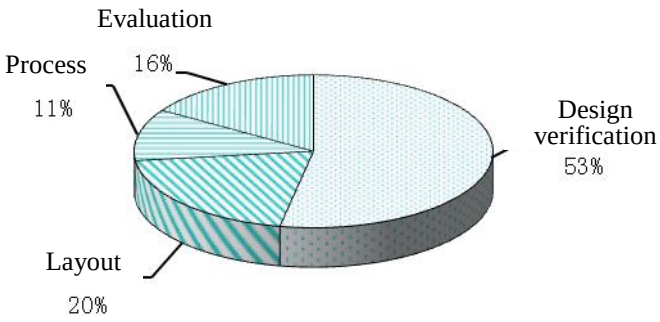

Figure 7. Business Fields of Engineers in the Semiconductor Group.

<3.4> Training for a semiconductor field assignment

Figure 8 shows the track record of special training conducted for engineers who were assigned in the past to the semiconductor field.

The special training, also illustrated in the flowchart of the training system shown in Figure 2, is training to implement subjects that the customer demands prior to assignment to a particular customer. When engineers work at a customer's site, in order to master basic knowledge in advance so that they can respond to as smoothly as possible, training has been conducted in cooperation with the customer.

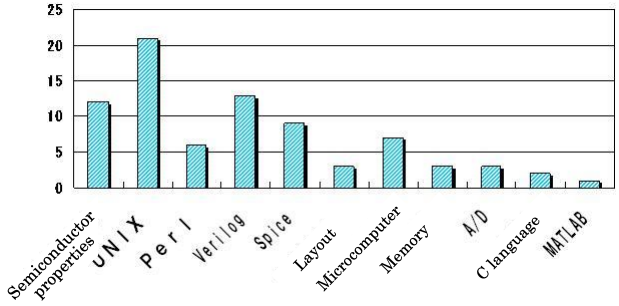

Figure 8. Results of Execution Number of Special Training.

This track record shows customer needs in the assignment of engineers, VerilogHDL, semiconductor properties and analog circuit simulation using Spice follow UNIX operation in the No. 1-position. Increasing the number of engineers of semiconductor G could be achieved as shown in Figure 6, because we implemented a detailed response to customer needs.

Figure 9 shows the training curriculum for a semiconductor field assignment.

Figure 9. Training Curriculum for Semiconductor Field Assignment.

If a training curriculum to assign new employees to the semiconductor field is constructed based on the track record of the number of special training implementations, it would resemble the flow diagram shown in the right-hand side of Figure 9.

The flow of the left-hand side is the course content for the electronic circuit field, but most business in the field of semiconductors is design verification work on

computers including layout design. We consider that it is effective to implement a high-demand curriculum in the semiconductor field in order to provide matching with a customer in a limited period of time, except for skill training. By implementing this flow, it is possible to shorten the training period and to assign an engineer early. From the track record of special training in the past, we judge it possible to shorten the period by about a month.

Evaluation of the technical textbook

<4.1> Training for assignment in the semiconductor field

Along with the construction of a training curriculum for the semiconductor field, we created "A way of thinking of practical design techniques—Chapter on semiconductors" in August 2009 as a technology textbook that is used in training [(2)].

This technology textbook has been created with the aim of educating engineers who match customer needs, and it is the fourth book in the series. The aim of the creation of the textbook is the following three points.

- The target is engineers who have been in the company for up to three years.
- The content is practical and improves ability.
- Teaching materials to train engineers in all cases.

The textbook was written by our chief engineer, who has conducted business on development sites and who also has worked on the development of young engineers; Professor Emeritus Shigeo Hirano of Tokyo City University planned the textbook and gave us instructions and advice from the first book onward; and Professor Takeshi Tanaka of Hiroshima Institute of Technology to whom we entrusted joint research into the development of teaching materials also helped in the creation of the textbook.

Figure 10 shows "A way of thinking of practical design techniques—Chapter of semiconductors," and Table 1 shows the table of contents and contents. The textbook consists of 286 A4 pages.

Figure 10. "A way of thinking of practical design technology" (Chapter on semiconductors).

Table 1

Table of contents of semiconductor textbook

Table of contents		Contents
Basic edition		
Chapter Ⅰ	Engineering Ethics	Basic stance and concept of "manufacturing"
Chapter Ⅱ	Semiconductor properties and devices	Knowledge of semiconductor physics and MOS structure, etc.
Chapter Ⅲ	Development process for system LSI	LSI design, manufacturing flow and description
Chapter Ⅳ	Transmission line	Concept and foundation of transmission line
Chapter Ⅴ	HDL	Grammar description of VerilogHDL and practice problems
Chapter Ⅵ	Development tools	Operating manual for Quartus Ⅱ and ISE
Chapter Ⅶ	Development environment	Knowledge of UNIX and Perl, and Perl practice problems
Application edition		
Chapter Ⅷ	Business content flow divided by design jobs	
Chapter Ⅸ	Embedded technology	Extensive knowledge involved in embedded technology
Appendix	Answers of practice problems, documentation of software Hardware	

Chapter I covers engineering ethics. The job of engineers is manufacturing, and Chapter I looks at engineering ethics that have become issues in the field of manufacturing these days, and it covers the basic stance of manufacturing as it applies to engineers. It is not possible to give satisfaction to customers and build a relationship of trust if this is missing.

Chapter II covers semiconductor properties and devices. It contains the summarized basic knowledge required for semiconductor engineers about the electronic properties of semiconductor band structure, PN junctions, MOS transistors and bipolar transistors.

Chapter III covers the development processes of system LSI. This is also a basic for engineers engaged in LSI development, the aim is to clarify the positioning of work in which they are involved.

Chapter IV covers transmission lines. Knowledge of this is necessary in businesses that deals with analog circuit design and high-speed digital signals in particular in addition to a basic knowledge of layout design.

Chapter V covers HDL. This is the mainstream of

our operations, it describes mainly VerilogHDL as well as practice problems.

As a development tool, Chapter VI is a summary of the operation of Altera's Quartus II and Xilinx's ISE that are used in training.

Chapter VII covers the development environment, centering on Perl script language and basic operation of UNIX and Linux. It may be surprising but, when we assign engineers to a customer, demand for these languages is the highest. Most development environments are on UNIX and engineers cannot use the development tool unless they have UNIX ability. In addition, it is Perl script that is used the most in the field as a scripting language.

Business content flow divided by Design Jobs in Chapter VIII is presented in common with all textbooks that we have compiled. This topic enables our employees to understand how work advances in Design Jobs.

Chapter IX is embedded technology. This may be outside the semiconductor field, but it is included because we want our engineers to know not only about the business areas in which they are currently working, but also about embedded technology in a wide context, and to put meaning to that we will link it to a textbook for control software that we are planning as the next book in the series.

We feel that there is no objection to being more difficult to teach than to be taught, but our chief engineer and engineers who work in the field have created manuscripts for this textbook. As a result, after publication of the textbook, our chief engineer has begun to take the initiative in creating new material, and the contents of the material are sophisticated. We have determined that an improvement of technical spontaneity and skills in our chief engineers and engineers was seen as a result.

<4.2> Questionnaire survey

We conducted a questionnaire survey on "A way of thinking of practical design techniques—Chapter on semiconductors." The purpose of this research is to determine whether this technology textbook is valid for future assignments in the semiconductor field. Table 2 shows the survey items.

Table 2

Questionnaire survey items

Items	Questionnaire		How to answer
Item 1	Appearance	Size and design	Superior: 5 points - Inferior: Answer in 5 stages of 1 point
Item 2	Usability	Clarity and ease of use	
Item 3	Contents	Simplicity of text, understanding of formula, visibility of charts, etc.	
Item 4	Composition	Composition of entire textbook	
Item 5	Practicality	Whether it is practical	
Item 6	Frequency of use	Frequency of use	
Item 7	Current business	Utility to current business	
Item 8	Future business	Usefulness to future business	
Item 9	Other comments and requests		Free comment

<4.3> Results of the questionnaire survey

Twenty-eight people took the questionnaire survey. They were 9 new employees who completed the VerilogHDL training using this textbook, and 19 engineers who have worked already at clients. The 19 engineers already have gained certain customer satisfaction, so we determine that it will lead to customer satisfaction if questionnaire results to them become high evaluation.

The aggregate results from the questionnaire are shown in Figures. 11 to 18.

The results for ease of use of this technology textbook are shown in Figure 11 and Figure 12. It was generally perceived as good, if we include "average."

Evaluation of the article content is shown in Figures 13 to 15, which show it was rated "should be practical," which is the aim of this textbook, if we include "average."

The survey results for actual business are shown in Figure 16 and Figure 17. Frequency of use and usefulness to current business are both lower when compared with the other survey items. This is because there were also engineers in semiconductor-related non-business in the questionnaire survey participants, and they already have knowledge related to current business, even if engaged in semiconductor-related business.

Figure 18 shows the results of the investigation as to whether this will be useful or not in the future.

Nearly 70% of engineers felt it to be useful, including "slightly higher." From these results, we determined that engineers feel that LSI in the center of today's design and development work and it must be supported in fields in the future and this textbook will help.

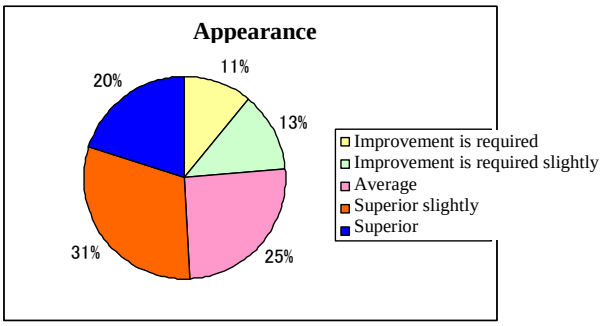

Figure 11. Questionnaire result (Item 1).

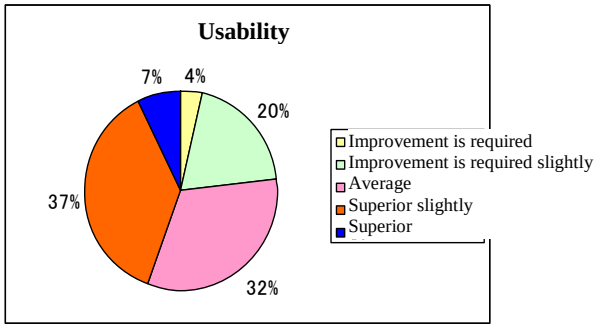

Figure 12. Questionnaire result (Item 2).

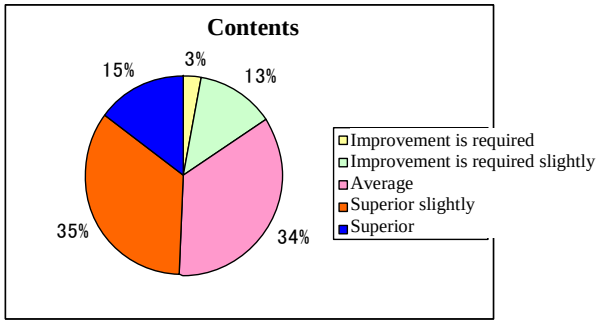

Figure 13. Questionnaire result (Item 3).

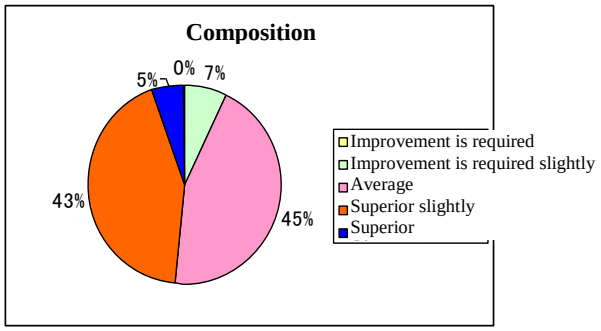

Figure 14. Questionnaire result (Item 4).

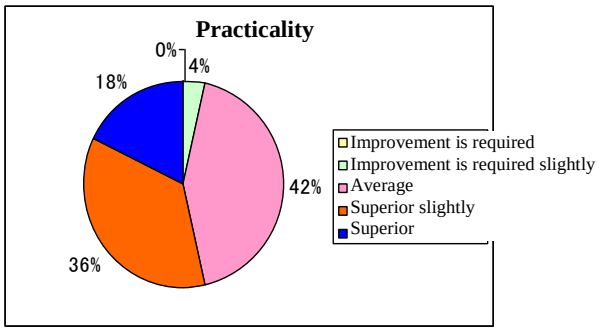

Figure 15. Questionnaire result (Item 5).

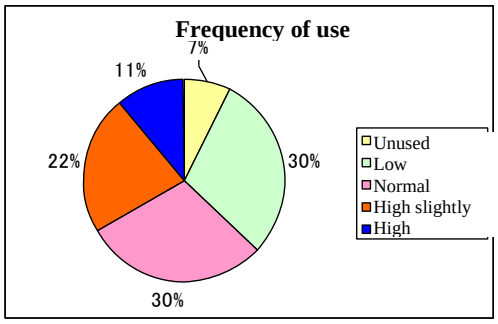

Figure 16. Questionnaire result (Item 6).

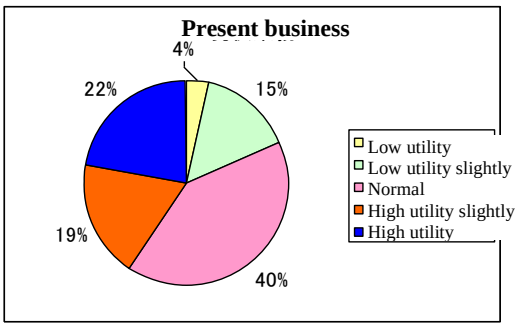

Figure 17. Questionnaire result (Item 7).

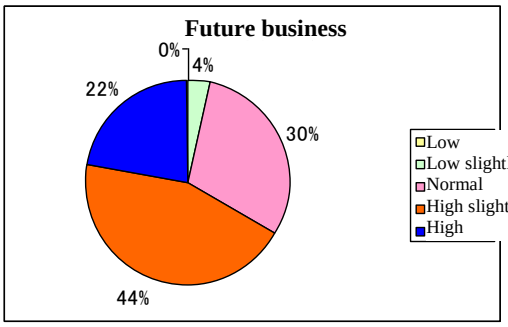

Figure 18. Questionnaire result (Item 8).

Conclusion

The technology textbook that we created, "A way of thinking of practical design techniques—Chapter on semiconductors" received high praise in terms of contents, composition and practicality in a questionnaire survey, and we determined that it can be

put to practical use as a text for training in order to assign young engineers and new employees to the semiconductor field. By implementing the training curriculum (flow) for assignment to the semiconductor field using this technology textbook, the following effects can be obtained.

1. Shortening of the period of training for assignment to the semiconductor field
2. Improvement in the efficiency of training
3. Improve the level of training

Our engineers who take the curriculum can show to customers that they have basic knowledge—of the content level described in the technology textbook we created. In contrast, the customers accept our engineers at contractual amounts of a certain amount. We provide technical skills, and the customers respond with the contract (accepting and contractual amounts). This gives confidence and peace of mind to customers as a result and leads to an improvement of customer satisfaction and differentiates us from other companies in the same industry.

We were able to compile this technology textbook based on the training curriculum used by Artner Co., Ltd. to assign new employees to new fields and the semiconductor field. In the future, we will revise this technology textbook in accordance with advancements in technology.

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