Courseware development for semiconductor technology and its application into instruction

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ABSTRACT

This study reports on the development of ESP (English for specific purposes) courseware for semiconductor technology and its integration as a “silent partner” into instruction. This kind of team-teaching could help overcome current problems encountered in developing ESP in Taiwan. The content of the material under discussion includes general knowledge about fundamental theories, process technologies and applications within the semiconductor industry. In the design of the whole courseware, five skills for learning English (listening, speaking, reading, writing, and translation) have been considered and a 3D multimedia technique has been used to promote learning interest, student engagement, and efficiency. The design of the courseware endeavors to mainly follow principles by [Mayer, R. E. (2001). Multimedia learning. New York: Cambridge University Press]. Students report they have benefited from the courseware implementation. Initial evaluations suggest that students are satisfied with practices for learning professional knowledge and English skills provided by the courseware. They report that the multimedia-assisted environment of the courseware promotes learning effectiveness. Students with higher achievement on the posttest showed better participation and motivation, made greater use of the multimedia and had a better understanding of the English content so that they are more competent to function in a professional and learner-centered ESP course using the courseware.

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1. Introduction

With the rapid development and fierce competition of business and industry, business communities around the world have deemed English language skills as an important tool to compete in the global economy (Graddol, 2006). Competence in English also plays a pivotal role in the success of one's career. In business, the semiconductor industry has become one of the most important industries worldwide, and over the last ten years has been offering many job opportunities in Taiwan. The 2007 Taiwan Semiconductor Industry Association Survey showed that Taiwan IC revenue totaled more than US$42 billion with a growth rate of 5.3% in 2007 (http://www.tsia.org.tw/Files/NewsFile/200832085316.doc). Thus, it is important to upgrade the level of knowledge regarding the industry's development and simultaneously improve English skills within the current system of higher education, because the combination will help students gain related abilities, including language skills, for potential future jobs.

One of the goals of foreign language education identified by the Ministry of Education of Taiwan for technical and vocational education is to provide students with the foreign language ability and advanced professional knowledge necessary to succeed in the job market (http://course.tvc.ntnu.edu.tw/download/curriculumoutline(Chinese title)/web/main.html). This development trend has caused ESP (English for specific purposes) instruction to be more greatly emphasized for the last few years at technical universities in Taiwan. ESP is well known as a learner-centered and content-based approach to teaching/learning English as a foreign language, which meets the needs of learners who need to learn English for use in their specific fields, such as business, science, technology, medicine, leisure, and academic learning (Hutchinson & Waters, 1987; Johns & Dudley-Evans, 1991). However, there are some problems in the development of ESP courses in Taiwan. Lai (2005) investigated the relationship of the English proficiency level of students in four universities of technology, their needs when taking ESP courses, and their expectations of an ESP teacher. Significant findings include: (1) sufficient qualified teachers, authentic materials and specific knowledge were not provided; (2) the target need of students taking ESP courses is to be able to apply language skills such as listening, speaking, reading and writing; (3) students need to have a higher level of English skills in order to perform well or attain a high level of learning in ESP courses.  

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With the explosive growth of e-learning, a technological revolution is currently taking place in higher education. E-learning is a learner-centered educational system which enables learners to learn whenever, wherever and whatever the learners want to learn according to their learning objectives (Rosenberg, 2001). Educational technologies provide numerous advantages in the areas of contextual, active, self-paced and individualized learning, and automation so that learners can choose appropriate learning content and paths themselves and understand their learning progress and achievement. This value and benefit corresponds to basic requirements of developing materials in ESP, in which content and method are based on the learner's needs.

Since computers have been widely used in schools as a tool for instruction, many developments in the field of CALL (computer-assisted language learning) have been made in the last few decades. Like ESP, CALL is learner-centered, which promotes self-paced learning. Integrative CALL provides a complete learning environment, including target content, personalization, feedback, remediation, and various learning and evaluation methods (Sung, Lin, Lee, & Chang, 2003; Taylor, 1980). It relies on the use of interactive multimedia which easily integrates languages skills (listening, speaking, reading, and writing), authentic learning experiments, learners’ control over their learning and a focus on the content (Warschauer, 1996).

Courseware, also called instruction or educational software, is widely used in higher education as an integral part of the courses. Courseware or multimedia integration into instruction has become a very effective tool for learning (Alessi & Trollip, 2001; Roblyer, 2003). Drawing lessons from the American experience, Sung, Chang, and Hou (2005) have suggested that the development of instruction-oriented software is one of the most important issues in promoting the e-learning industry in Taiwan. In general, courseware can play the role of a tutor, a tool, or a tutee. Interactive multimedia courseware for CALL can be divided into several categories, based on the emphasis of the courseware. Some studies stress that CALL is useful for improving the learner’s varied linguistic skills (Levy, 1997; Warschauer, 1996). In this discussion, the development of ESP courseware focuses on drill and practice, tutorial, tests, web-based learning, hypermedia, and simulations.

Although courseware development and its applications in classroom lectures is becoming more greatly emphasized, its design and use have been more focused on courses related to courses and technology (Azemi, 2008; Jiménez & Casado, 2004; Li, 2004; Shamsudin & Nesli, 2003). That is because instructors in these fields have more competent skills and knowledge of multimedia software and programming so that they are less hesitant to convert their lecture notes into an interactive package that can be available to students. Consequently, the effectiveness of these new instructional tools has not been fully realized or studied in ESP which is an interdisciplinary task that emphasizes coordination and integration of learning technical knowledge and English skills.

The main objective of ESP is to allow learners to communicate effectively in the tasks prescribed by their studies or work situation (Tsai & Lee, 2005; Tsai & Wang, 2007). Teaching students how to communicate effectively and appropriately in English in different situations, is one of the major goals of the English curriculum in Taiwan’s universities. With the rapid development of Taiwan’s technology industries, effectively improving English oral and written communication ability applied to the field of technology industries is more emphasized on many university campuses during the past few years, but its instruction has not been implemented as well as in business ESP courses, mainly due to task complexity and lack of qualified teachers.

2. Purpose of the study

In order to work out a possible solution to overcome problems in ESP development, and to meet student needs, a relevant and authentic ESP courseware for the semiconductor industry was developed. The integration of the developed ESP courseware into instruction let computers play a central role in helping students repeatedly practice English skills with first-language (L1) audio. Students were able to learn and construct professional knowledge through their direct interaction with the courseware supported by the professional teacher’s intervention. In that sense, the courseware acted as a team-teacher, affecting the performance, motivation, and attitude of students, which has been examined in this study.

3. Design of courseware for instruction

The courseware design, including its choices of features for instruction, was conducted under the ‘ADDIE’ (Analyze–Design–Develop–Implement–Evaluate) framework (http://itsinfo.tamu.edu/workshops/handouts/pdf_handouts/addie.pdf). ESP courseware for semiconductor industry was developed and then integrated into instruction for students of applied foreign languages department (AFLD) in a Taiwanese technical university. The effectiveness of students’ content learning was evaluated by the pre- and post-test respectively conducted before and after the courseware integration. In addition, this study used two Likert-style questionnaires to elicit student motivation for learning and attitude toward content. The methodology of this study is divided into two phases, courseware design and curricular implementation, and will be discussed in that order.

Computer-aided instruction (CAI) approach combined with sustained-content language teaching (SCLT) approach where students “learn language through the medium of a single content area” was adopted (Murphy & Stoller, 2001). A major feature of SCLT is its dual focus on sustained content and language teaching, which includes two major components: a focus on the exploration of a single content area, or carrier topic and a complementary focus on L2 learning and teaching (Pally, 2000), which provides scaffolding to enable students to develop the language skills and professional knowledge necessary to succeed in the target (Murphy & Stoller, 2001). The first component is related to instruction in a specific subject area for a period of time; the second one concerns the instruction in language learning, such as the development of vocabulary, pronunciation, grammar, reading, writing, speaking, listening and translation; and cognitive and metacognitive strategies.

By being given a clear and logical structure and content through courseware, students are expected to become engaged in a virtual learning environment through which professional knowledge and language skills can be acquired and constructed. In order to provide a learning environment where students use the target language as if they were in real-life situations, the courseware design was based on the situated learning theory and the cognitive apprenticeship model which suggests skills be acquired and constructed through authentic contexts and by communicating with peers and experts about those contexts (Cheaney & Thomas, 2005; Kevin, 1999). Situated cognition is a theory of instruction that suggests learning is naturally tied to authentic activity, context, and culture (Brown, Collins, & Duguid,
enables learners to practice applying English skills. The structure of the professional content knowledge is explained as follows:

3.1. Courseware design

The background analysis for the courseware was conducted by reviewing literature and surveying related courseware on the market. Although the semiconductor industry is very important in the development of the larger engineering-based industry in Taiwan, there is no related ESP courseware applied in instruction in higher education here, in which professional knowledge and five skills for learning English (listening, speaking, reading, writing, and translation) are emphasized. That was the initial and underlying reason for undertaking this study: to design courseware for students in higher education, or people working in or interested in related fields. The design concept of the courseware is key to practical on-the-job application through integration of the five English skills mentioned above. The courseware design is essential to the effective use of multimedia and educational technology so that the interaction between the meaning and media can be conducted in the learning process. The courseware attempts to incorporate major principles for the effective use of multimedia: modality, contiguity, multimedia, personalization, coherence, redundancy, pre-training, signaling, and pacing (Mayer, 2001; Moreno & Mayer, 2000). In the courseware, authentic English texts with L1 audio and corresponding Chinese translation support, narration, practices of language skills, on-line tests with instant checking, graphical images and multimedia movies are all presented in the courseware, both temporally and spatially contiguity principle (Mayer, 2001). They are implemented in learner-paced segments so that students can control their learning pace and educational experience for repetition, deliberate practice and self-evaluation with the courseware, corresponding to the pacing principle: the pace of presentation is controlled by the learner, rather than by the program (Mayer, 2001).

The content of the courseware is laid out with simplicity and consistency, and is in both English and Chinese so that the target audience of this courseware can be ESL college or university students and adult learners with lower English proficiency. The content is divided into three thematic sections: Introduction to the semiconductor industry; Theories and manufacturing technologies of semiconductors; and Evaluation system. Each section includes several topics, each with several learning activities or on-line tests. In addition to offering an overview on the development and application of semiconductors, a variety of theories and manufacturing technologies commonly used in the industry are provided in each topic with narration and animation to lead students into visual and virtual contexts and to engage in meaning-making. Such an animation design with narration is destined to promote a better transfer and performance on retention tests as stated in Mayer’s multimedia principle (Mayer, 2001) so that the learners’ zone of proximal development (Vygotsky, 1962) is increased, enabling them to construct their verbal and visual cognitive representations and integrate them for the task requirement. Thus, the well-structured content of the courseware plays a scaffolding role to help students develop or improve ideas, knowledge and language skills for semiconductor technology.

The activities include technical content and its relevant vocabulary, proper pronunciation, reading, listening, speaking, translation, and questions for learners to practice applying English skills. The structure of the professional content knowledge is explained as follows:

<table>
<thead>
<tr>
<th>Basic steps to develop the courseware.</th>
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<tbody>
<tr>
<td>Background Analysis</td>
</tr>
<tr>
<td>Data mining &amp; Selection</td>
</tr>
<tr>
<td>Structure &amp; Production of Content</td>
</tr>
<tr>
<td>Consultation / Editing / Translation / Evaluation</td>
</tr>
<tr>
<td>Digitization of Content</td>
</tr>
<tr>
<td>Texts / Audio / Video / Images</td>
</tr>
<tr>
<td>Multimedia Design</td>
</tr>
<tr>
<td>Integration of Content System</td>
</tr>
<tr>
<td>Testing, Consultation &amp; Modification</td>
</tr>
<tr>
<td>Completion of Courseware</td>
</tr>
</tbody>
</table>
3.1.1. Semiconductor industry

The section includes three introductory texts with L1 audio: *Introduction to Semiconductor, Process Technologies of Integrated Circuits*, and *Application of Integrated Circuits*, in order to help learners understand the development and application of semiconductors, as well as to establish and enhance their interest and cognition in the semiconductor industry. These texts are chosen for the intermediate-level language learner, in the sense that the sentence structure is at the level of ordinary newspaper reportage, and other than technical terms related to the industry, the lexicon is comprised of relatively familiar and highly frequent words from the wordlists One and Two developed by Nation (2006).

3.1.2. Theories and manufacturing technologies of semiconductors

Seventeen sets of multimedia movies together with English and Chinese texts have been designed to briefly explain basic principles, related manufacturing technologies and applications of integrated circuits, which bring learners into a virtual context of semiconductor technology. In addition, the layout of the multimedia movies with their texts is based on learner-paced segments rather than a continuous unit, corresponding to the segmenting principle proposed by Mayer (2005). The English explanation was made as brief and as accessible as possible, about 100 words for each movie, in order to decrease text complexity as a learning barrier. The topics of this section are divided into three parts (Tsai, 2006):

- Six topics are related to basic principles of semiconductors, including introduction to atomic structure, introduction to silicon, lattice structure of silicon, single crystals and polycrystalline, energy band structure and semiconductors, and intrinsic and extrinsic semiconductors.
- Seven topics concern technologies for the main manufacturing technologies of integrated circuits, including preparation of wafers, thermal oxidation, ion implantation, photolithography, etching, diffusion, and formation of thin film.
- Four topics are related to the application of integrated circuits such as bipolar diode, solar cells, light emitting diode (LED) and metal oxide semiconductor (MOS).

3.1.3. Evaluation system

In order to create an interesting, motivating and friendly learning environment, several questions that use the multimedia game-like format have been devised for all topics in the second section. This on-line evaluation system combined with an instant reference function helps learners test themselves and monitor their learning progress and achievement.

3.2. Curricular implementation

The courseware was implemented as a seven-week module incorporated in a semester-long optional course, “English for Technology”, offered for AFLD students of the day-time four-year program in a technical University in Taiwan. They had no background in the semiconductor industry at all. Since the course was optional, students took it based on their own interest and need, which typically makes them more activated and engaged in meaningful learning. The course was conducted in the multimedia laboratory of the department. All students in the class were assigned individually to computers in order that they could study by themselves with the courseware according to their schedule. The courseware could be accessed through the Intranet of the laboratory. The sustained-content language teaching (SCLT) approach was adopted, and the design of the course was as follows:

1. Goal: the aim of the course was to promote students’ knowledge about semiconductor technology, as well to improve their English vocabulary. Through the pre-test, students can get a clearer understanding about the overall objectives and requirements of the course, and the skills that could be improved by interacting with the courseware.
2. Target audience characteristics: the AFLD students in the day-time four-year program have studied English for eight years at least: six years in junior and senior high school and two years in college. They were considered to have higher English proficiency. Their background and job experience included no semiconductor technology at all.
3. Teacher: the teacher was the researcher who developed the courseware for the project. The teacher has semiconductor technology academic background and has been employed in that field. Currently, he teaches in the higher vocational education system and focuses on research on the development of ESP courseware, particularly for technology and commerce. The teacher mainly played the role of a content teacher and facilitator, using the courseware as the silent partner in the team-teaching approach.
4. Teaching content: the courseware was installed on the server in the laboratory so that students could easily access and learn the content of the courseware on his or her computer after the teacher’s explanation for each topic. In general, two or three topics were given each week depending on the complexity of the topic.
5. Courseware integration: in effect, the courseware played the role of an adjunct content and language teacher through which learners could have the total freedom of exploring the content and practicing related language skills. In that sense, the courseware was a major medium for delivering and transferring technical knowledge. Since the aim of this effort was mainly to study the learning effectiveness from using the courseware, the teacher played a role of supervising and observing students’ behaviors and learning, controlling the schedule, and encouraging students’ interaction with the courseware. Based on the request of an individual student, the teacher also acted as a coach by giving further explanations, one-on-one, during class. During the whole learning process, students took an active role to learn or practice any target content or English skills that they needed and were interested in.
6. Assessment: a pre- and post-test was conducted to provide students’ learning performance or evidence. The two written tests were similar, including ten simple questions asking students to briefly explain or describe related terminology or process technologies, such as a p–n diode, photolithography and its process, or package and its purpose. The pre-test allowed learners not only to preview the task objective, but to think ahead how to do the task and plan the knowledge and language they need which helped stimulate students’ engagement.
Table 2
Background of the students who completed all the tests and questionnaires (the number in the parenthesis is the number for the male group).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Male</th>
<th>Female</th>
<th>Score group</th>
<th>High</th>
<th>Intermediate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd Grade</td>
<td>0</td>
<td>1</td>
<td>12 (3)*</td>
<td>20 (3)*</td>
<td>12 (2)*</td>
<td>1</td>
</tr>
<tr>
<td>3rd Grade</td>
<td>8</td>
<td>36</td>
<td>8</td>
<td>36</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>4th Grade</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

(7) Questionnaire survey: an internal questionnaire with 14 items was administered at the end of the self-study/course to elicit students’ responses concerning the suitability of the courseware content and its usage, their perception of how it might support English learning, language acquisition, multimedia and evaluation assisted learning, and navigation of the courseware. A second, external questionnaire was administered by the academic office of the school in the end of the course to elicit information about the self-discipline and motivation of students, their self-evaluation on learning effectiveness and on teaching methodologies and materials that were delivered in class.

The content-specific vocabulary is important to the sustained-content topic because these words support students’ content learning, performance of academic tasks, and use of learning strategies (Donley & Reppen, 2001). Thus, in the beginning of learning each topic, students had to learn the technical vocabulary or terminology from the teacher's preliminary oral explanation, and then read the text of the topic. The technological and theoretical aspects of the content were difficult for students to understand, so the teacher also used multimedia 3D visuals built into the courseware to display and reinforce the content. After the teacher's explanation, students were asked to self-study with the courseware, and meanwhile were allowed to work or discuss in pairs or groups or to resort to other resource aids through Internet.

Finally, interviews with graduated students, who took this technical ESP course with the courseware integration and are currently working in related fields, were conducted to understand the practical application and usefulness provided by this team-teaching approach.

3.3. Subjects

There were in total, 64 AFLD students who took the course of which 52 students completed the pre- and post-test, and responded to the two questionnaires: 48 were valid. The high/low groups are based on the posttest score: the highest 27% for the high group; the lowest 27% for the low group. The background of the students is given in Table 2.

4. Results and discussion

4.1. ESP courseware for semiconductor technology

The three sections of the courseware, Introduction to the Semiconductor Industry, Theories and Manufacturing Technologies of Semiconductors, and Evaluation System, are prominently shown on the main page when learners access the courseware, shown as HTML format in Fig. 1. This allows learners to resort to other resources through the Internet as desired. Each session is followed by topics and related learning activities, presented as buttons or icons. By clicking on any button or icon, learners can access to the content and activities that they need or are interested in. Such a learner-centered and logical layout provides students with a user-friendly environment including a clear interface and guidance, and navigation aids, which corresponds to the principles of Guided-discovery, Navigation and Site map in the Advanced Principles of multimedia learning proposed by Mayer (2005).

The three introductory texts in the first section (Introduction to Semiconductor, Process Technologies of Integrated Circuits, and Application of Integrated Circuits) are designed to help learners understand the development and application of the semiconductor industry. After clicking any text button in the section, a pop-up learning screen with the section title will appear, shown in Fig 2. A window shows in the middle of the screen where the text and learning activities including professional knowledge and English skills (listening, speaking, reading, writing and translation) are provided. On the right side of the window, the function keys for learning language skills are shown. The operation mode of the function keys is given below:

- Terminology: the terminology of the text is highlighted to reduce cognitive load, corresponding to Mayer’s signaling principle (Mayer, 2005). The Chinese translation is provided on the left side of the screen, and its color will change when the cursor is on the corresponding vocabulary, as shown in Fig 2.
- Pronunciation practice: when the pronunciation practice button is clicked on, the color of the paragraph will change when being spoken, like karaoke style, shown in Fig 3. This game-like function is destined to facilitate learner’s pronunciation improvement, reading focus, and listening skills. Such a subtitled-multimedia courseware with L1 audio is similar to subtitled-video, which can positively enhance performance in listening and speaking, and promote a more efficient comprehension for L2 learners (Herron, Morris, Secules, & Curtis, 1995; Lund, 1991; Rubin, 1994). Meanwhile, this multimedia message with words presented with spoken language corresponds to the modality and multimedia principles, which facilitates learners to construct verbal and visual cognitive representations and integrate them (Mayer, 2001).
- Speaking practice: after clicking on the speaking practice button, the L1 audio becomes mute, which allows learners to practice their speaking and reading skills by themselves. Meanwhile, learners can record his or her voice through the recording program provided with Microsoft Office.
Listening test: after selecting the listening test, a blank window will pop up on the screen for learners to key-in what they heard. Answers are also provided just below the key-in window after clicking the Reference button. It provides an instant checking feedback in order that learners can monitor their progress and examine themselves immediately.

Chinese translation: the Chinese translation is simultaneously shown on a pop-up window just below the text after clicking the Translation button, as shown in Fig. 4. This bilingual support will allow learners to have a better comprehension, as well to practice English translation and writing skills.

The second section includes 17 topics together with texts and animated movies that describe the theories and related manufacturing processes of the semiconductor industry, as shown in Fig. 5. As explained earlier, because some theories and technologies of semiconductors cannot be clearly understood through the texts alone, multimedia movies have been designed for each topic to create a virtual reality learning environment that will help learners get a better understanding. The images of the manufacturing process about package extracted from the multimedia movie are shown in Fig. 6. This design corresponds to Meyer’s temporal and spatial contiguity principles, stating that corresponding narration and animation are presented simultaneously and near rather than far from each other on a page or screen by means of which better transfer occurs (Mayer, 2001). In addition, multimedia movies are only played by clicking the corresponding icon.
so they are not visually presented with their text simultaneously, which does not overload visual working memory capacity and corresponds to Meyer's redundancy principle (Mayer, 2001).

The third section is the evaluation system. To create an interesting, motivating and friendly learning environment, the interface of the system is designed with an animated and game-like format. All the questions have been devised for all topics in the second section. After clicking the Evaluation button, the question in English and Chinese and a blank window for the answer will appear. Learners only need to key in their answers in English in the blank window, and then the reference answer can be provided by clicking the Answer button, as shown in Fig 7. This on-line evaluation system combined with a reference function allows learners to get immediate positive feedback in learning, which helps learners understand their learning progress and achievement.

The design of the whole set of materials to include professional knowledge about semi-conductors, presented through five language sills (listening, speaking, reading, writing and translation), is emphasized via authentic text, audio, and visual communication by multimedia which is destined to helps learners to gain broad access to learn the target subject both visually and auditorily. Meanwhile, authentic materials provide rich, comprehensive and flexible input that allows learners to focus both on meaning and form (Tscharner, 2001). Since learners have the total freedom of practicing all the above learning activities at their own pace and learning need, this advantage of the pacing principle in e-learning allows learners to have enough time to engage in the cognitive processes of selecting, organizing, and integrating what they acquire in the learning process in a fearless and unconstrained environment.
4.2. Student satisfaction

A questionnaire of satisfaction was processed after finishing the seven weeks of instruction with the courseware integration. The questions of satisfaction target the following elements, such as teaching method, improvement of professional knowledge, English learning skills including listening, speaking, reading, writing, translation, and terminology, professional content and English relevance, multimedia and evaluation assisted learning, and navigation of the courseware (Tsai 2007; Tsai & Davis 2008). All valid responses were input and filed for statistical data analysis using SPSS. This analysis, doing the independent samples t-test, focuses on the gender and the groups of high/low posttest score in order to understand if there is significant difference existing among the factors mentioned above. An acceptable significant level for each statistics was at .05 in this study. Students responded to each item using a 5-point Likert scale ranging from 1 to 5, including very satisfied (5), satisfied (4), average (3), not satisfied (2), disliked (1).

In addition, an external online questionnaire containing 15 items was administered in the end of the course. All the items in the questionnaire can be divided into three parts: self-discipline and motivation of students (items 1, 2, 3, 4 and 6), students' self-evaluation of learning effectiveness and performance (items 12 and 13), and teaching methodology and material that the teacher gives (items 5, 7, 8, 9, 10, 11, 14 and 15). A 5-point Likert scale was also used for each item in the questionnaire. The choices students selected for each question of the questionnaires were averaged and the standard deviation (STD) was analyzed.

Having no background about semiconductors, the students could not correctly answer all the questions in the pretest. The mean of the posttest for the 48 students who had completed the pre- and post-tests and administered two questionnaires was 67.0. All the students
made much progress in the posttest and the paired samples t-test analysis shows that there is a significant difference in students’ grades between the pre- and post-test, indicating that the effectiveness of content learning was significantly improved after seven week’s participation and learning.

Before the implementation of the courseware into curriculum, the course had been taught to 180 students of the same program during three successive academic years. The questions given in these three years were similar to those in this study. The mean grade of those 180 students in the posttest was 73.2 which was little lower than 76.0, mean grade of the 64 students in this study. This result implies that the courseware did play a role of tutor so that the student-centered instruction with ESP courseware implementation was as good as the teacher-centered one, even with a little higher mean grade. Analysis through an independent samples t-test found no significant difference existing in students’ grades before and after courseware implementation.

4.2.1. Result of the questionnaire of satisfaction

The returned questionnaires were analyzed through SPSS. The Cronbach alpha reliability for the questionnaires was 0.918, indicating that the collected data were highly reliable. The results of the questionnaire are listed below in Table 3. Student responses to the questionnaire have given much to think about. As the satisfaction questionnaire administered by users can be considered to be their learning motivation or results (Long, 1985; Tough, 1982), seven issues are highlighted:

1. You are satisfied with the teaching with the courseware 4.08 (0.65)
2. The courseware improves your cognition in semiconductor technology 4.00 (0.62)
3. The courseware helps in learning English for Semiconductor Technology
   3.1 Overall 3.92 (0.54)
   3.2 Listening skills 3.69 (0.72)
   3.3 Speaking skills 3.56 (0.74)
   3.4 Reading skills 3.92 (0.71)
   3.5 Writing skills 3.65 (0.60)
   3.6 Translation skills 4.00 (0.68)
3.7 Vocabulary of technology 4.13 (0.67)
4. The professional content of the courseware is relevant 4.00 (0.62)
5. The English of the courseware is relevant 3.85 (0.58)
6. The multimedia movies of the courseware assist learning 4.17 (0.75)
7. The evaluation system of the courseware assists learning 3.90 (0.72)
8. The function keys improve navigation 4.17 (0.63)
9. The overall average score 3.93 (0.66)

...
The questions 6 (multimedia assisted learning, \(M = 4.17\)) has the highest score. It reveals that the inclusion of multimedia leads to enhance the transfer of information and knowledge to learners. The original design of the courseware was focused on creating a multimedia-assisted environment which could act out real-life experience so that the motivation and interest of learners and their learning effect were promoted. Positive response here was gratifying.

The questions 8 (navigation, \(M = 4.17\)) has also the highest scores. It suggests that a user-friendly learning interface design of the courseware should be considered first, especially for ESP courseware with professional or technical content because it can add pedagogical value to the application and promote learner’s motivation which has been considered one of the key factors in L2 learning. According to Gardner and Lambert (1972), attitudes and motivation have strong relation to language achievement no matter how the learners’ aptitude and intelligence may be. Having studied the variables that might affect 1200 FL (foreign language) learners’ strategy use, Oxford and Nyikos (1989) found that motivation had the most powerful influence on the choices of language learning strategies. Thus, strong motivation leads to positive attitudes, and consequently learners can learn well in the process of learning their target language. The original design of the courseware was focused on creating a user-friendly learning environment which could promote interest and motivation for sustaining learning. The positive response was confirmed here.

A higher score for Question 3.7 (terminology learning, \(M = 4.13\)) reveals that, for EFL (English as foreign language) students in Taiwan, vocabulary is seen as a key factor in improving reading skills, and increasing vocabulary comprehension is seen as the most effective reading strategy (Yi, 1994), especially in ESP courses. It indicates that it is necessary for instructors to teach students content-specific vocabulary, which has semantic ties and conceptual relationships with the target content. It allows students to have a better understanding of lectures, texts, and class discussions.

Another high score for Question 1 (teaching with the courseware, \(M = 4.08\)) means the integration of the courseware into instruction was supported by the students. In fact, the fullest collaboration for ESP teaching is often said to be one where a subject expert and a language teacher team-teach classes (Johns & Dudley-Evans, 1991). However, such teaming has not been feasible in vocational education in Taiwan for several reasons, such as lack of qualified teachers, difficulties of collaboration or relevant curriculum design. Thus, the ESP courseware incorporating L1 audio with paragraph subtitles can be an instructional tool to help Chinese students of English practice language skills and promote their comprehension. In case the fullest collaboration for ESP teaching is not feasible, this team-teaching approach is suggested to be applied for technical and professional domains by expert teachers who can use the target language to help learners establish content-specific vocabulary and critical knowledge with semantic ties and conceptual relationships with the professional content so that learners’ meaningful learning regarding the specific field or purpose can be facilitated.

The Question 3.6 (translation, \(M = 4.00\)) has a higher score, suggesting that translation can help learners get a better understanding and comprehension of professional knowledge in studying such a technical ESP course, further enhanced by corresponding animated movies and the teacher’s explanation.

The scores for learning English skills from Q3.1 to Q3.6 are 3.56–4.00, higher than the average, or 3. It indicates that the courseware provided enough practices for training English skills, which can meet the need of Taiwanese EFL students in learning this ESP courses. The scores for speaking (Question 3.3, \(M = 3.56\)) and writing (Question 3.5, \(M = 3.65\)) skills are a bit lower than the others. It is probably due to less progress or achievement that could be made in these skills because productive skills such as speaking and writing are more difficult to learn than receptive skills like listening and reading (Ali, 2007; Blanchard, Mason, & Daniel, 1988; Greenfield, 2003). It could be improved by developing related activities such as blogs as a potential solution to writing, and direct audio recording or podcasts as a possibility for oral practice as reviewed by Godwin-Jones (2005) and Chinnery (2006).

If compared by gender, the general mean value of male students is 3.95 while it is 3.93 for the female students. A further analysis through the independent samples t-test shows that no significant difference exists between the male/female groups.

If the high and the low score groups are compared, the general mean of the high score group is 4.11, while it is 3.80 for the low score group. Further analyzed by different questions, almost all the means of the high score group for each question are higher than those of the low score group. It reveals that the high score group not only more focuses on practices of English skills and related evaluation activities, but also is more satisfied with the content and design of the courseware and its application in teaching and learning. Thus, the courseware is more recommended by the high score group.

Further analysis through the independent samples t-test between the high/low score groups shows that there is a significant difference existing in Q1 (teaching with the courseware), Q5 (English content) and Q6 (multimedia assisted learning), shown in Table 4. Since all the means of these three questions for the high score group are higher than those of the low English score group by 0.42–0.66, indicating that the students in the high score group have a better understanding of the English content of the courseware and make more use of multimedia in their learning process so that they are more competent to learn such a professional and learner-centered ESP course with the courseware. This result corresponds to Lai’s investigation on the relationship of the English proficiency level of students in four universities of technology that students need to have a higher level of English skills in order to perform well or attain a high level of learning in ESP courses (Lai, 2005).

4.2.2. Result of the online external questionnaire

The external online questionnaire contained 15 items which are divided into three parts: self-discipline and motivation of students, students’ self-evaluation of learning effectiveness and performance, and teaching methodology and material that the teacher gives, shown in Table 5. The returned external online questionnaires were analyzed through SPSS. The Cronbach alpha reliability for the questionnaires was 0.952. The results of the questionnaire are listed in Table 5.

The results show all the mean values of the questions for the high/low score groups are higher than 4, and moreover the mean values of the high score group are higher than those of the low score group by 0.14–0.72. It indicates that the students in the high score group gave themselves a better self-discipline, understanding and performance in learning motivation and effectiveness. If the mean for each item between the high/low score groups is compared, the two bigger differences are 0.72 on item E1 (attention in class), and 0.71 on the item E9 (content relevance). It implies that, for students in the low score group, although the content was more difficult to learn, they paid less attention in class, which would make their learning much more difficult than for students in the high score group.
### Table 5
Analysis of results of the external online questionnaire.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Without courseware (N = 163)</th>
<th>With courseware integration (N = 48)</th>
<th>Levene test F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1. I pay attention in class</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.58 (.52)</td>
<td>4.42 (.50)</td>
<td>.699*</td>
</tr>
<tr>
<td>High</td>
<td>4.08 (.81)</td>
<td>4.27 (.71)</td>
<td></td>
</tr>
<tr>
<td>E2. I go to class on time</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.64 (.48)</td>
<td>4.50 (.51)</td>
<td>.289 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E3. I usually preview before the class</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.44 (.54)</td>
<td>4.50 (.51)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E4. I usually review after the class</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.10 (.57)</td>
<td>4.08 (.58)</td>
<td>.515 .519</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E5. I understand what is taught in class</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.15 (.55)</td>
<td>4.08 (.50)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E6. I always attend the class</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.37 (.60)</td>
<td>4.27 (.49)</td>
<td>1.033</td>
</tr>
<tr>
<td>High</td>
<td>4.07 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E7. What is taught corresponds to the teaching goal</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.34 (.7)</td>
<td>4.23 (.69)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E8. The teaching materials and handouts are rich</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.29 (.80)</td>
<td>4.25 (.70)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E9. The teaching content is relevance</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.29 (.76)</td>
<td>4.19 (.79)</td>
<td>.515 .621</td>
</tr>
<tr>
<td>High</td>
<td>4.07 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E10. The teacher makes use of the material and gives a systematical</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>explanation</td>
<td>Low</td>
<td>4.29 (.79)</td>
<td>1.033</td>
</tr>
<tr>
<td>High</td>
<td>4.07 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E11. The teacher gives examples or use auxiliary tools to facilitate</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>learning</td>
<td>Low</td>
<td>4.29 (.76)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E12. I get some professional knowledge and skills</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.31 (.77)</td>
<td>4.21 (.77)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.07 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E13. The abilities of thinking, analysis and problem-solving are improved</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.23 (.81)</td>
<td>4.31 (.62)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E14. The preparation and attitude of the teacher is serious and careful</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.37 (.76)</td>
<td>4.35 (.64)</td>
<td>.834 .000</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
<tr>
<td>E15. I recommend others to take this course</td>
<td>Mean (STD)</td>
<td>Mean (STD)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.37 (.75)</td>
<td>4.31 (.73)</td>
<td>.515 .809</td>
</tr>
<tr>
<td>High</td>
<td>4.00 (.7)</td>
<td>4.08 (.7)</td>
<td></td>
</tr>
</tbody>
</table>

* N = 107 (there is no this item in the on-line external questionnaire for the first teaching year).
* p < .05.
** p < .01.
A further analysis through the independent samples t-test between the high/low score groups indicates, shown in Table 5, there is a significant difference existing in the items E1, E2 (on time to class), E6 (attendance in class), E7 (teaching goal understanding), E8 (teaching materials and handouts), E9, E10 (teacher’s explanation) and E11 (use of auxiliary teaching tools). These differences support the inference drawn above that less disciplined students show a worse participation and motivation in attending the class, which would cause them to have less practices and interaction with the courseware and the teacher. In addition, such students had less understanding about the teaching goal and were more likely to have a dependent learning style and less self-directed learning behavior, and a lack of an internal locus of control so that they needed more extra learning support to study ESP courses, such as more teacher’s explanation, teaching materials and handouts, and auxiliary tools.

In the case of studying without courseware integration, 163 students validly completed the on-line external questionnaire. Since in the first teaching year there were no E2, E3, E4 and E5 items in the questionnaire, 107 were valid. The result is listed in Table 5. All the mean values of the questions for the instruction without courseware are close to those for the instruction with courseware and their difference is only between 0.02 and 0.14. After the analysis by the independent samples t-test, there is no significant difference between these two instructions.

4.3. Interview with graduated students

Five students who had followed the ESP course using the semiconductor courseware, who graduated in 2007, were randomly selected for an interview which was conducted by a questionnaire with some open-ended questions. They all have been working in semiconductor- and technology-related fields for more than a year. Three of them returned the questionnaire in which they commented on the team-teaching's effectiveness and usefulness in providing them with professional knowledge, practices of English skills, and communicative aids at work. Student A: due to less interest in learning something about chemistry or electronics, she had failed in the posttest with a score of 27; this score was higher than what she had made on the pretest but much lower than 60, the required score. Of course, she never anticipated working in the semiconductor field. However, after an unintentional interview she was hired by Orient Semiconductor Electronics Company (Taiwan) which provides a broad range of high value-added IC packaging and testing services and electronics manufacturing services. She and her family thought it would be a favorable plan to work in a well-established semiconductor company. Thus, she quit her teaching job in a cram school and tried her chance in the semiconductor field. Now she is working as a process engineer and handles problems encountered in the manufacturing process to improve production yield. There are lots of foreign workers with whom she needs to frequently speak English; in addition, she always uses English for writing at work. She replied that:

- I remember that we used courseware to practice listening at that time. It helps me understand more and know how to pronounce unfamiliar words.
- In my opinion, the course does help me to understand the semiconductor industry basically. I gradually realize how useful and important it is and I would like to learn more about it, if possible, for self-expectation and self-learning that are important in the increasingly competitive job market.
- It is necessary to design and arrange relevant English courses at semiconductor companies and courseware can be integrated in an on-line learning platform.

Student B: she is working as a sales and service secretary in an agent company (CORREMAX International Company in Taiwan) which imports automation equipment and component of vacuum and optics from North America and Europe. She uses 70% of her working time for writing to and communicating with foreign manufacturers in English for orders and shipment, or for asking some problems about component supply and maintenance under the request of salespersons or engineers. She replied that:

- I think the advantage of learning the course is to increase my cognition or knowledge about technology. Some learned concepts or knowledge is helpful to find possible solutions to resolve related technical problems encountered at work, as well to have more interaction with people working in the related field.
- Students need a higher English proficiency to take the course in order to cope with what is taught in class.
- The relevant and qualified teacher is very important for the course, which would not make students (especially for AFLD student with less technology background) refuse to take this difficult course. Fortunately, the way of what I have been taught was very clear and interesting.
- Since the content of the courseware focuses on helping establish general view on semiconductor and its manufacturing processes, the content of the courseware needs to add more practical details if the course is used for on-job training in industries.

Student C: she works as a sales engineer in the Taiwan branch of an international engineering company (ABB Group) which business focuses on power and automation. On behalf of her customers, she uses 95% of the working time for writing to and communicating with engineers of the company in English, who come from Sweden, Swiss, Finland, America, England, Japan, Korea, to report back to the engineers as to what the problems are and work out the customers’ problems. She replied that:

- This course does allow me a better understanding and comprehension in reading technical documents at my present work.
- More diverse and practical authentic materials can be offered in the course, such as catalogs and technical reports.
- If possible, more learning activities can be added in the course for improving the ability of creative thinking and problem resolving.

According to the interview results, all agreed the course could be part of the undergraduate curriculum. But the qualified teachers and students' English proficiency need to be considered in conducting such a technical and professional course. In addition, the course did help them have a better understanding and knowledge about the semiconductor industry and they think it is useful and important for their current jobs. It implies that the content of the courseware basically meets industry needs. Meanwhile, it is suggested that more practical
materials and learning activities can be added in the course and some relevant English courses can be offered at workplaces to promote on-
job training.

5. Conclusion

Before the courseware was implemented into the curriculum, the course had been taught with a textbook for three academic years. The
main objective of the course is to help students establish basic knowledge or cognition of being an assistant in business or engineering for
companies in the semiconductor field that provides more job opportunities. The instruction was more focused on terminology and content
learning, rather than language learning. It was a challenging experiment and an interdisciplinary task to teach a new, practical and tech-
nical course in AFLD departments since AFLD students typically had less interest and background in science and technology. Thus, how to
promote students’ motivation in learning such a technical and professional course remains one of the very important concerns, especially
with about 60 students in a class each semester.

In the beginning, the textbook and many PowerPoint files were used to demonstrate and explain basic principles and manufacturing
processes that usually are not easily understood by students with the less academic backgrounds of ADLF students. Even though terminol-
ogy, principles, and manufacturing processes were introduced and reviewed, a number of individual students still repeatedly asked for fur-
ther explanations. As a result, the instruction became boring, inefficient and complicated. Enhancing the instruction with multimedia
courseware became a possible solution.

In this study, ESP courseware is examined and evaluated as a way to identify possible solutions to problems in the development of ESP
courses in Taiwan. This preliminary investigation finds that:

1. The courseware provides an authentic material for learning ESP on semiconductor technology. It incorporates professional knowl-
edge of semiconductor with the basic skills of English learning. Included are vocabulary usage, pronunciation practice, speaking
opportunities, translation practice, listening practice, short answer writing exercises.

2. Based on a comparison of scores between the pretest and posttest, students were benefited and improved their English skills and
professional knowledge from the team of the courseware and the professional teacher. Moreover, students’ performance was as good
as that in the teacher-centered instruction. It reveals that the courseware played the role of an adjunct content and language teacher
providing the opportunity for learners to study professional knowledge and practice language skills.

3. The original design of the courseware was focused on creating a multimedia-assisted environment that can act out real-life experi-
ence. Such a virtual multimedia did enhance the transfer of information and knowledge to students and made them get a better understand-
ing of the target subject.

4. As for the learning attitude and behavior of students observed through the questionnaire results, the students with higher achieve-
ment on the posttest showed better self-discipline, participation and motivation in attending the class. Meanwhile, they made more
use of multimedia and had a better understanding of the English content in their learning process so that they are more competent to
learn such a professional and learner-centered ESP course with the courseware integration. However, less disciplined students had a
poorer understanding about the teaching goal, and needed more extra learning support to study ESP courses.

Based on the feedback and the experience from applying the courseware into instruction, the implementation of another ESP course-
ware into instruction is being examined, this time using the situational context of a trade fair. The students’ performance in content learn-
ing and language use are simultaneously studied. Students are asked to process the target language pragmatically to achieve different types
of tasks such as making a plan or budgeting for a trade fair, which provides more data about the effectiveness of English learning with the
courseware. As a result, students’ improvements in content learning and English skills such as writing and listening have been observed.
This research is aimed at developing a multimedia courseware for practical instruction. When used in classes, the students can call on both
the professional teacher’s intervention and the multiple media presenting the content of the courseware. Such courseware integration
could be a beginning solution to overcome current problems encountered in the development of ESP courses in Taiwan.

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References


