Simulation Based Printing Engineering Education for Women in Engineering Students in South Korea

Jong Tae YOUN* and Song Ah CHOI
Pukyong National University, Busan, 48547, South Korea
*Corresponding author

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Abstract. To increase the retention rate of women engineering students as human resources of the field of Graphic Arts and Printing (GAP) industries in South Korea, we introduced the simulation based engineering education method and developed the screen printing simulator for same purpose. Before setting up this education method, factor analysis for female engineering students at P University, which is a model university in South Korea, was conducted. The analytical results showed that social and cultural effects are more significant ones than social effect alone, and the effects of gender discrimination in industrial fields. Also results showed responses that the physical differences between man and women students, such as the ability to drive printing machines or to handle tools, their parents’ financial support for experiments, and the gender cognitive engineering education. In this research, we developed the measurement tool to measure women students’ competencies in GAP industries and contributed to make the women in engineering education according to the results of factor analysis. These researches have been progressed since 2006 annually, and we had proposed to programs for the gender cognitive engineering education and the special programs for women engineering students. The retention rate of female engineering students was increased from 30% at 2006 to over 50% in 2016. And the rate of women students who change their major from 5% to decreased 1 %. According to the lecture evaluation, 98% of women students were very satisfied the simulated education method. So we found that the factor analysis and the simulated engineering education system for GAP women students have progressed successfully.

Introduction

Graphic arts and printing engineering is one of the compromising industries to make a cellular phones, textiles, shoes, or motors etc. in South Korea. However we have a problem that we have a small numbers of female engineers in the field of graphic arts and printing industries. The population of South Korea is about 50 million, and the half of population 25 million is women and only about 10% of women engineers were engaged in GAP industries compare to 90% of man at 2006. Indeed South Korea has continued its dramatic economical growth since 1950 after Korean War by women workers. Many of the women were engaged in textile manufacturing or wig industries. However the lack of national women power resources is a serious problem. Moreover women engineering students still have wanted to change their major because then are faced with a glass wall or glass ceiling of male dominant culture, circumstances that preferring males to females. Many of women students had withdraw from engineering school temporarily, and about 5% of women students changed their major from engineering to some other major or dropped out of completely in P University until 2006 (Youn, 2011). So, one of the governments important campaigns is the promoting and supporting women engineers in the industrial field. An increment of female engineers, human is an important national undertaking not only for the national economics but also for improving the quality of women’s life and social status. These situations are almost same in some other nations such as Japan or USA(Lapkin, 2010). Female students are not interested in GAP as well as engineering related activities and consistently experienced much more difficulties than male students in engineering and science (Wolffram, 2009). Discrimination of women engineers in the GAP industrial field is still real
worldwide problem (Park, 2009). Even though we have made improvements against, it is still devastating throughout the world. Women students can be discriminated and be experienced the prejudice not only at college, but at all sociological and cultural levels at home or in their society, either directly or indirectly. South Korea stands with circumstances of the worst gender pay gap and the worst glass ceiling index among the Organization for Economic Corporation and Development (OECD) nations. Therefore, it is necessary to understand how women engineering students’ thoughts differ from those of male students and why more female students than male students dropped out of college. Because of complex concepts such as sociological status, college educational systems, individual or personal problem, or individual scales corresponding to the female students’ dropout phenomena, the factor analysis for investigating variable relationships was used. To find the factors that contributed to the female students’ mind to dropout, we conducted both in-depth interviews and a questionnaire survey. The questionnaire was framed on the basis of the women students’ thoughts and the experiences in their campus life. According to the results of preliminary experiments, we found that over 50% of the women students at GAP departments wanted to change their major from engineering. To understand the situation of GAP departments in South Korea, P University was selected for this research. Number of students in GAP department in P are about 400 and about 50% of the student in 2014. Also P University is a leading university of women in engineering program and has a GAP engineering department. Similar researches have been progressed since 2006, and we have presented at the conference of quality in higher education (Youn, 2015). And we need to make an advanced research to the framework of factor analysis and to perform annually to conduct a follow up survey.

Factor Analysis of Women Students Dropout from GAP

The definition of dropout and the manner in which it is defined are not consistent, comparisons are difficult to make, and when comparisons are made, analysis may be faulty. There have been many attempts to identify the dropout (Morrow 1986). It is classified dropouts by Morrow into five types, such as the push out of school after being judged as disqualified, the unaffiliated persons who refused to associate with others, the voluntarily dropout who leave the school as the college and the family demanded different scales from the students, the educational mortalities who are not able to complete the coursework, and the stop out students who will return to school. However in this research for the special purpose to increase the retention rate of women students at GAP departments, we focused and limited the dropout refers to the willing of discontinuing coursework at a GAP departments. In other words, for a quantitative factor analysis we calculated the dropout as the women students who initially entered in the GAP departments but quit the school or transfer to some other major field instead of GAP engineering. The factors that predict whether students dropout or change their major from engineering fall into four categories: (1) individual factors, (2) domestic factors (3) sociocultural factors (4) college educational factors (Youn 2016). Boshier reported that the phenomena of dropping out increase when the internal harmony with one’s self does not match the harmony of one’s self with the environment (Oh, 2006; Boshier, 1973). More macroscopic analysis offered nine factors for dropping out such as the idealistic self, the trust in one’s self, the adequacy of the process, the level of achievement, available support for individual students, control by the educational institution, mismatch of the ego with the super ego, the clarity of objectives and academic competence (Garrison, 1987).

The main objective of this study is to identify the reason why women students at GAP department are not interested in their major program and why they wanted changed their major. Factor analysis of women engineering students’ dropouts from GAP engineering was attempted to identify the selected factors or variables that explain the pattern of correlations within a set of observed variables. Source data were obtained by conducting both in-depth interviews and a questionnaire survey. A quantitative measurement tool was developed on the basis of the factors that reflected the characteristic features of women engineering students’ mind. These were extracted from the interviews. The validity and
reliability of the measurement tool were confirmed by applying SPSS 21 software. In descriptive statistical analysis, standard deviations were below 0.1% whose Skewedness and Kurtosis were above ±2.0. For the reliability test, we used Cronbach’s alpha coefficient. Cronbach’s alpha value of 0.5~0.6 is considered as relatively good and alpha value above 0.7 is good enough to be accepted (Nunnally, 1976; Lee, 1991). In this research, we used Varimax of the right angle rotation method for the rotation method. The number of factors was determined by using the Scree plot, eigenvalue, gross dispersion rate of more than 60%, and interpretation potentials, and the validity was confirmed through the eigenvalue, the common dispersion versus gross dispersion rate, and the interpretations of the content.

To collect the data, we interviewed random 20 women engineering students who changed their major from GAP departments and another 20 students attended in GAP department. The depth-interview is a qualitative method of analysis, which proceeds as a confidential and secure conversation between interviewer and a respondent. The interview ensures that the conversation encompasses the topics that are crucial to ask for the sake of the purpose and the issue of the survey (Boyce & Neale, 2006). An in-depth interview took place in a private home or her room in dormitory, where the respondents are in their natural surroundings. The survey questionnaire was given to 200 women engineering students including 20 women students who changed their major from college of engineering. Total of 180 cases were collected through a random sampling method by means of questionnaires and questions were put to the respondents to measure the levels of satisfaction. Survey questionnaire also collect the coed information about students’ opportunities to learn both in and out of the classroom as well as students’ experiences. The framework for questionnaires, developed in 2006 and advanced for this research in 2015, could guide the collection and responding of women engineering students’ information. Survey questions undergo a multi step response based development process before being used. This process includes preliminary testing questions with small samples of students as well as piloting draft questions to large samples (Youn 2016).

Table 1. Formulated framework of questionnaire.

| Questions | Individual Factors                                  | Domestic Factors                                      | Sociocultural factors                               |
|-----------|-----------------------------------------------------|-------------------------------------------------------|------------------------------------------------------|
| Item 1    | Interesting of GAP major                           |                                                       | Society’s prejudice against women engineers          |
| Item 2    | Intention to change the major                       |                                                       |                                                     |
| Item 3    | Friends effects                                     |                                                       |                                                     |
| Item 4    | GAP major agreement                                 |                                                       |                                                     |
| Item 5    | Consistency between GAP major and your goal         |                                                       |                                                     |
| Item 6    | Job recruiting                                      |                                                       |                                                     |
| Item 7    | Difficulties of coursework in the majoring field    |                                                       |                                                     |
| Item 8    | Motivation of selecting your major                  |                                                       |                                                     |
| Item 9    | Information on the engineering field at the time of selecting the program |                                                       |                                                     |
| Item 10   | Satisfaction of the curriculum of the major         |                                                       |                                                     |
| Item 11   | Availability of consultants (mentors) to discuss your individuals |                                                       |                                                     |
| Item 12   | Possibility of continuing a job in the field you are majoring in |                                                       |                                                     |
| Item 13   | Inner conflict about your major                     |                                                       |                                                     |
| Item 14   | The main agent that decides your career and your satisfaction |                                                       |                                                     |
| Item 15   | Parents’ perception of GAP engineering               |                                                       |                                                     |
| Item 16   | Financial assistance of your family                  |                                                       |                                                     |
| Item 17   | Part time work and payment of your school expenses  |                                                       |                                                     |
| Item 18   | albeit                                               |                                                       |                                                     |
| Item 19   | Parents’ occupations                                |                                                       |                                                     |
| Questions |                                                     |                                                       |                                                     |
| Item 1    |                                                     |                                                       |                                                     |
Simulator for GAP Engineering Education

It is well known that using computer simulation based teaching and learning methods has many merits and advantages for engineering students and their parents who give an assistance to the students. And we found that those methods would affect to students especially for females. However there was no screen printing simulation software for education, so we made a simulation software for this purpose, which named screen printing simulator (SPS) as shown on Figure 1.

![Screen Printing Simulator](image1)

Figure 1. The main screen (a) and a example of learning procedure (b) of our SPS software.

Also we introduced and used the offset and Gravure simulator which has made by Snaps company in France as shown on Figure 2. And we were analysed the effectiveness of simulation based teaching and learning method.
Simulators are classified into different categories. Simulators can be classified according to their resemblance to reality. We tried to design the SPS simulator to resemble the reality using Flash, C++ language and Photoshop etc. By using SPS software which we developed, students can get printing results according to the change of printing speed, pressure and angle of squeeze, and respond either automatically or manually to physical and chemical interventions.

Results and Discussion

Why use Simulation in GAP Women Engineering

The results of factor analysis have verified the contracted four factors of the women students’ dropout measuring tool which consisted of five preliminary test categories such as individual, domestic, social, cultural and college educational factors. In the factor analysis was looking at the educational factors of the negative gender cognition learning environments, responses showed that similarity as women students experimented in GAP departments, they perceived the male dominant cultures in business and industrial field. Also from the results shows that GAP departments should be provided with the opportunity to develop gender cognitive program and cabiculum for female students so as to avoid a more difficulties then male students in GAP engineering education. However, in many GAP engineering classes and lectures included lab experiments which were not aware of how to measure women engineers’ individual, social, cultural, environmental, and technical competencies. Therefore, this measurement tool developed in this study can be used to measure women students’ competencies in college of engineering and to make a program for women in engineering (WIE) education (Enyegue, 2004; Liao, 2007). In addition, tuition is more expensive for GAP engineering departments then other pure science departments because of load of laboratory expenses. And many of Korean women students have a tendency to rely on their parents while American woman students have an independent mind, most of expenses of tuition and living expenses are assisted or provided by their parents. Therefore we added to the factors of household situations, and we found their parents assistance helps significantly motivates women engineering students’ study(Damassa, 2010). So, it is necessary to provide an additional social and academic support program in order for boosting women students’ capability and for improving the retention rates in GAP engineering. To solve these obstacles such as educational factor (Grant, 2006; Bauman, 1967) obtained from the results of factor analysis, we introduced the simulation method for GAP engineering education. Items factor analysis was performed to verify the reliability and validity of the developed measurement tool in this research. The test score on the reliability of the items of female engineering students were between .656 and .882, respectively. These results are comparatively high score for the obtained results in a field of social science. (See Table 2).

| Factors            | Cronbach’s alpha |
|--------------------|------------------|
| Individual Factor  | .882             |
| Domestic Factor    | .656             |
| Sociocultural Factor | .829             |
| Educational Factor | .713             |

Table 2. Reliability scores.
Based on the results of the factor analysis, faculties in GAP engineering students or in South Korea can use the measurement tool for a better understanding of the mind of dropping out of women students by measuring above four competencies. Table 3 shows the results of individual factors and classified new items related to individuals. Factor 1 on Table 3 refers to the satisfaction of her major because the score of Item 9 (the information on the GAP engineering field at the time of choosing her major) and the score of Item 8 (the time to determine her major) shows the highest scores, respectively. Factor 2 refers to the influence of the circumstances because the value of Item 3 (students’ friends who changed their GAP major from engineering and classmates or friends who took a leave of absence) was .807. Factor 3 refers to the accommodation and networking with classmates and faculties because it is a factor concerning the counselors on her anxiety of her major program or getting a job after graduation. Factor 4 refers to recruiting and continuing her engineering career. The Eigenvalue of variance that we calculated are a measurement of how much of the variance of the observed variables a factor explains. Any factor with an eigenvalue ≥1 means more variance than a single observed variable. Same as individual process, as shown on Table 4, the domestic factor was consisted of five items. Factor 1 refers to the financial conditions and Factor 2 refers to the parents’ assistance.

Table 3. The results of factor analysis of individual factors.

| Questions | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|-----------|----------|----------|----------|----------|
| Item 9    | .871     | .128     | -.049    | .107     |
| Item 8    | .852     | .248     | -.040    | -.047    |
| Item 10   | .723     | .181     | .301     | .271     |
| Item 13   | .483     | .213     | .299     | .481     |
| Item 7    | .451     | .388     | .068     | -.170    |
| Item 3    | .092     | .817     | .174     | .381     |
| Item 1    | .150     | .781     | .338     | .160     |
| Item 2    | .160     | .823     | -.111    | .097     |
| Item 5    | .467     | .638     | .351     | -.114    |
| Item 11   | -.142    | .111     | .798     | .111     |
| Item 14   | .498     | .012     | .581     | .234     |
| Item 4    | .527     | .301     | .550     | -.214    |
| Item 6    | -.104    | .147     | -.061    | .811     |
| Item 12   | .297     | .088     | .391     | .691     |
| Eigen Value | 3.222    | 2.581    | 1.881    | 1.781    |
| Percentage | 22.981   | 18.381   | 13.712   | 13.082   |
| Variance  |          |          |          |          |

Table 4. The results of factor analysis of domestic factors.

| Questions | Factor 1 | Factor 2 |
|-----------|----------|----------|
| Item 18   | .881     | -.132    |
| Item 17   | .862     | -.030    |
| Item 16   | .792     | .208     |
| Item 19   | -.148    | .891     |
| Item 15   | .487     | .771     |
| Eigen Value | 2.524    | 1.856    |
| Percentage | 46.912   | 23.214   |
| Variance  |          |          |          |
Table 5. The results of factor analysis of educational factors.

| Questions | Factor 1 | Factor 2 | Factor 3 |
|-----------|----------|----------|----------|
| Item 2    | .721     | -.050    | .061     |
| Item 4    | .671     | .081     | .078     |
| Item 5    | .691     | .057     | .117     |
| Item 6    | .581     | .401     | .051     |
| Item 3    | .512     | -.090    | .464     |
| Item 12   | -.167    | .681     | .328     |
| Item 9    | -.001    | .671     | -.040    |
| Item 10   | .387     | .623     | -.382    |
| Item 8    | .189     | .579     | .025     |
| Item 1    | .251     | -.167    | .615     |
| Item 7    | .178     | .181     | .521     |
| Item 11   | -.310    | .401     | .529     |
| **Eigen Value** | **3.614** | **2.112** | **1.891** |
| **Percentage** | **18.512** | **17.812** | **12.618** |

The college educational factor consists of three categories (see Table 5). Factor 1 on the Table 5 refers to the circumstances of engineering campus and the relationships between female students and male faculties because factor 1 involved the items 2 through 6 related to gender cognitive teaching and learning method. Factor 2 on the Table 5 is composed of items for existence of special program for women engineering students such as computerized simulation method for women students. Factor
2 refers to gender cognitive engineering education. Factor 3 on the Table 5 refers to gender cognitive curriculum and workforces for women engineering students. The score of factor 3 was .615 which was the highest value. Table 6 shows the results of factor analysis of the sociocultural factors. We composed five items on the sociocultural factor. Factor 1 on the Table 6 refers to the perceptions in society or industries to the women engineers because the score of Item 2 (gender difference in competition) and Item 3 (business owners’ perception of women) played an important role. Factor 2 refers to the discrimination against female engineers and the score of item 14 concerning the culture of engineering fields and the glass ceiling index item was .798. Factor 3 on the Table 6 refers to the job recruiting and Factor 4 refers to priority of man for employment or promotion etc. and Factor 5 on the Table 6 refers to her role model in engineering.

According to the result of factor analysis, one of the most important steps in curriculum development is the introduction of simulation based GAP engineering teaching and learning. Simulation is a term that refers to an artificial representation of a real printing process to achieve educational goals through experiential learning. Table 7 is a summary of strategies to solve a problem.

| Factors              | Advantages of SPS                                      |
|----------------------|-------------------------------------------------------|
| Individual Factor    | Giving the interest                                   |
| Domestic Factor      | Parents’ support reduction                            |
| Sociocultural Factor | Solve the gender issues, Prepare for change           |
| Educational Factor   | Both teach and skill                                  |

Simulation based GAP engineering education is defined as any educational activity that utilizes simulation aides to replicate printing press operators. Although GAP engineering simulation is relatively new, simulation has been used for a long time in other high risk professions such as aviation. A trainee can make mistakes and learn from them without the fear of harming the machine. It has many advantages for not only woman students but men students and obstacles for women in engineering can be covered using simulation method.

**Simulation Based GAP Education**

Simulation based education method is an excellent teaching method for many skills but especially for GAP female engineering students. Learning in engineering is most effective when the level of women students is different. Some of the women students’ family is pressman otherwise other students have had no experience to training GAP fields. Another important feature is that students receive immediate feedback. Simulation is an excellent way to both teach and practice skills (Morgan 2002). Traditional learning methods focused on physical training. Simulation is a method of learning that allows or requires learners to apply theory to practice in an integrated manner. Simulated education method can avoid danger and loss of expenses of laboratory training and conditions can be varied and outcomes investigated. Also simulation based education method has an advantage that critical situations can be investigated without risk and that it is cost effective. And it can be sped up so behaviour can be studied easily over a long period of time. However it has the disadvantage that it is very difficult to make a simulator and it can be expensive to measure how one thing affects another, to take the initial measurements, to create the model itself, and to simulate something a thorough understanding is needed and an awareness of all the factors involved, without this a simulation cannot be created.

**Retention rate of Women Students**

These researches have been progressed since 2006 annually, and we had proposed to programs for the gender cognitive engineering education and the simulation based GAP engineering education for women engineering students. The retention rate of female engineering students was increased from 30% at 2006 to over 50% in 2016. And the rate of women students who change their major from 5%
to decreased 1%. According to the lecture evaluation, 98% of women students were very satisfied the simulated education method.

![Figure 3. The rate of retention rate of women students at department of graphic arts and printing (GAP) (a), and the percentage of women students in GAP department.](image)

**Conclusion**

To increase the retention rate of women engineering students of the field of Graphic Arts and Printing (GAP) industries in South Korea, we introduced the simulation based engineering education method and developed the screen printing simulator (SPS) for same purpose. The results of factor analysis showed responses that the physical differences between man and women students, such as the ability to drive printing machines or to handle tools. Those two obstacles were covered by simulation based education method. Also, parents’ financial support to students reduced as a decrease the cost for experiments. In this research, we developed the measurement tool to measure women students’ competencies in GAP industries and contributed to make the women in engineering education. These researches have been progressed since 2006 annually, and we had proposed to programs for the gender cognitive engineering education and the simulation based education for women engineering students. The retention rate of female engineering students was increased from 30% at 2006 to over 50% in 2016. And the rate of women students who change their major from 5% to decreased 1%. According to the lecture evaluation, 98% of women students were very satisfied the simulated education method. So we found that the factor analysis and the simulated engineering education system for GAP women students have progressed successfully.

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