ISSN 2409-2665
Journal of Logistics, Informatics and Service Science
Vol. 9 (2022) No.1, pp.274-290
DOI:10.33168/LISS.2022.0117

An Innovative Career Management Platform Empowered by AI, Big data, and Blockchain Technologies: Focusing on Female Engineers

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Abstract. With the advent of the fourth industrial revolution, professional resource management in the engineering sector has been gaining importance. And countries around the world are paying special attention to realizing and using the potential of female engineering talent that has been on the rise. Nevertheless, there is still a leaky pipeline of female engineering talent. As such, this study aims to provide a new platform that incorporates the latest technologies to promote female engineering talent. First, it introduces the existing career management platforms developed for female engineering students, along with their limitations to become a lifelong career management platform. In addition, the study proposes a customized career management platform for female engineering talents in line with their life cycles, empowered by artificial intelligence, big data and blockchain technologies which are characteristic of the fourth industrial revolution. With the help of a career management platform reinforced by such latest technologies, career interruption and a loss of female engineering talent will be prevented, and through sustainable career management of talent, the overall national competitiveness will be enhanced.

Keywords: Career management platform, female engineers, artificial intelligence, big data, blockchain, gender gap

1. Introduction

In the advent of the fourth industrial revolution, knowledge and information have become new sources of value creation. And amid social changes, the development and maximization of human resources has become the most important topic of our times. Notably in the engineering sector which requires advanced professionalism, creativity and innovation, more value is being placed on professional talent development. Recently around the world, countries are paying special attention to realizing and using the potential of female engineering talent that has been on the rise. However in spite of that, the employment rate of female engineering majors is on a steady decline. As of 2018, the employment rate of female engineering majors was 22.4% at best (Ryu, Jang, 2020). This shows how difficult it is for female engineering students to start careers in their chosen fields, compared to their male counterparts. Given the engineering sector environment and its demand for creative talent, proactive efforts should be made to address the issue of female engineering talent management. Because female engineering talent management is not just part of some affirmative actions for minorities but is the crucial piece in realizing social justice, making social contribution in engineering and developing the engineering talent.

In step with such trend, there have been various efforts made by the government and universities in the Republic of Korea. Women in Science, Engineering and Technology (WISET) of the Ministry of Science and ICT offers a female engineering talent academy, and WISET mentoring and job search services for young female engineers via WeDoDream which is a job portal for engineering students (WISET, 2021). And the Ministry of Education has been supporting female students to keep developing their engineering talent and potential by reforming engineering colleges and promoting female engineering talent through the Women in Engineering - Undergraduate leading Program (WE-UP) (Korea Ministry of Education, 2016). As recipients of the aforementioned program, ten universities, including Ewha Womans University, focus on improving their curricula in line with social demand, supporting career, employment, start-up plans of female engineering students in line with their life cycles, and promoting a woman-friendly educational culture and environment in engineering (Ewha Womans University, 2021).

Furthermore, they have developed a career management platform for their female engineering students to nurture their career competencies, and conducted studies to validate its educational efficacy (Jang, 2021). This career management platform is based on a role model portfolio to reinforce the career competencies of female engineering students and effectively manage their employment quality. Role models have positive effects on their studies and career motivation, and can result in starting major-related careers. Hence, it is very important to set a role model while on campus. Students search their role models on the platform and set career goals, and while accumulating and organizing experiences that are toward achieving their

career goals on the platform they can systemically examine their growth process and check achievement against it on their own.

Nevertheless, the above platform only records activities which students take part in during the university years, and hence has limitations to make connections with any post-graduation employment activities. In other words, students cannot add post-graduation information to the platform, which makes it impossible to manage their post-graduation career information. Also, since the platform only allows students to record and manage their university activities, the scope of activities and information available on the platform is limited. Therefore, to overcome such limitations there needs to be a platform which comprehensively incorporates information beyond the university years. What's more, a more effective and lifelong platform is needed which takes full advantage of the latest technologies (AI, big data, blockchain and others) to overcome the limitations of the existing platforms. For example, when a female engineer with career interruption due to child birth or care looks for a job, the platform becomes either a two-way information provider that checks job listings from recruitment agencies and connects her to recruiters, or a lifelong platform where she records all her career activities and takes up the role of a mentee or mentor in professional communities.

As such, Chapter 2 of this study reports the current gender gaps found in the engineering sector both at home and abroad, and in Chapter 3, the career management platforms that were recently developed for female engineering students are introduced along with their limitations. In Chapter 4, proposals are made to reframe the existing career management platforms with the technologies of the fourth industrial revolution, including AI, big data and block chain. Finally, Chapter 5 concludes with a summary of the aforementioned contents and future recommendations.

2. The engineering gender gap

Cases both at home and abroad have been examined to understand the existing engineering gender gaps. First was the global engineering gender gap. The engineering gender gaps found in the US, Canada and the European Union were investigated, centering on North American and European cases. Then, the current domestic engineering gender was examined, along with specific cases where female engineering talents were supported.

2.1. Global gender gap

The global engineering gender gap was investigated, centered on North American and EU cases. Let us first look at the Canadian cases. In Canada, though women take more than a half of the workforce, women engineers with working licenses are less than 13% in the entire country (Engineers Canada, 2018). In the STEM (Science - Technology - Engineering -Mathematics) sectors, women's participation

in the chemistry and biology sectors is on par with that of men, however in the engineering sector, women's participation is poor. Doctor Mary A. Wells Ph.D. examined a loss of female engineering talent (Wells et al., 2018). A summary of her research findings is in Fig. 1. When explaining the female engineering talent, she used the metaphor of a leaky pipeline to describe the phenomenon. The metaphor of a leaky pipeline is often used in explaining a loss of female talent occurring in all stages of female engineers' career. As shown in Fig. 1, less than 20% of the engineering undergraduates in Ontario are women, which is similar to the overall Canadian level. Hence, there is a clear gender gap in engineering, despite steady improvement in female representation. A need for female talent promotion and management in engineering, apart from general STEM areas, should be recognized and addressed with a sense of urgency.

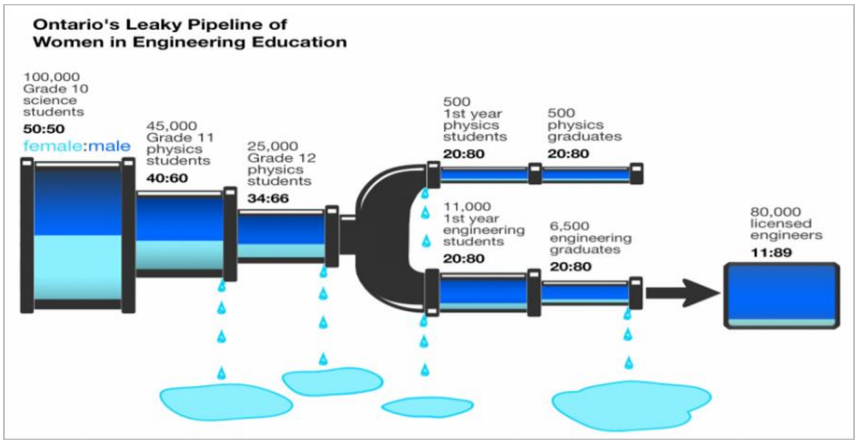

Fig. 1: Leaky pipeline in Ontario with the 2016 data

In the United States, women take almost a half of the workforce just like Canada, but there are only few women working in the STEM sectors. In 1970, women made up 38% of the entire workforce in the United States and 8% of the STEM workforce. In 2019, women accounted for 48% of the entire workforce and the percentage of women in the STEM workforce rose to 27%. On the other hand, men made up 52% of the entire US workforce in 2019 but accounted for 78% of the STEM workforce (The U.S. Census Bureau, 2021). This is direct evidence that men still dominate the STEM sectors.

The percentage of women in the STEM sectors has increased since 1970, and there have been noteworthy increases in the fields of mathematics and sciences. The percentage of women employed in the fields of mathematics and sciences, rose from 19% in 1970 to 64% in 2019. And as of 2019, there were a lot of women working in the fields of mathematics (47%), and biology and physics (45%). However, though computer and engineering make up the lion's share (80%) of the STEM workforce, the percentage of women in these sectors has not moved much. Women account for

about one fourth of the computer workforce and 15% of the engineering workforce. The percentage of women employed in the engineering sector has indeed gone up from 3% in 1970 to 15% in 2019. Furthermore, the percentage of women working in the computer sector had risen since 1970 but dropped between 1990 and 2019 (American Physical Society, 2018). According to the US statistics. 40% of engineering majors either did not take up major-related jobs or quit them in the end (Wells, 2018). As such, a variety of research has been conducted in the United States as people began to recognize a shortage of female engineering talent as an issue. In connection with this study, a need for women's career path development has been raised (Silim, Crosse, 2014).

In Europe, there are more women scientists and engineers than in the United States, but progress is still slow. For the past ten years, though there has been steady progress in Europe, yet a gender gap among scientists and engineers still persists in Europe. According to the official statistics from Eurostat, 41% (6.3M) of the scientists and engineers aged between 25 and 34 in EU were women (Lago, 2021). As shown in Fig. 2, women accounted for more than 50% of the workforce in the science and engineering sectors in only six out of 36 countries surveyed for the statistics including non-EU countries such as Norway, Switzerland and Turkey.

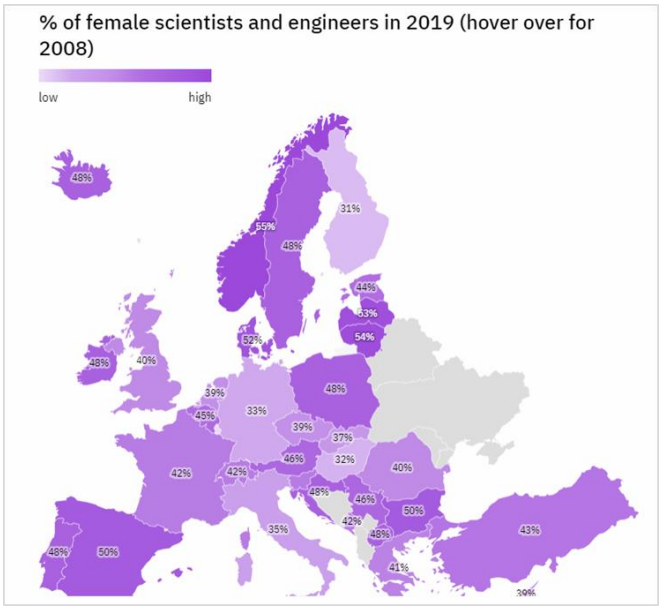

Fig. 2: Percentage of women scientists and engineers in EU countries: based on the 2019 data

Ever since these statistics started to be recorded, Norway was the first country that topped the ranking with women making up 55% of the scientists and engineers,

followed by Lithuania with 54%. And next in the rankings were Latvia, Denmark, Bulgaria, and Spain. In North Europe, Denmark went through the biggest change. In 2008, women scientists and engineers made up 30% but in 2019 the percentage increased a lot and rose to 52%. Though Poland, Ireland and Belgium showed the percentages higher than the EU average (41%), yet the numbers of women in the science and engineering sectors dropped, compared to 2008. In Poland and Ireland, the percentages rose to 54% and 52% respectively at some point in time, however they both dropped to 48%.

A country that is worth looking out for due to a low percentage of women scientists and engineers is Luxembourg which was the only country in Europe where the percentage of women scientists and engineers was less than 30% in 2019. Since 2008, Luxembourg has made an improvement of a mere 6%, reaching 28% today. And Finland is a country with the second lowest percentage where the percentage has risen by 6% to 31% since 2008. Unlike other North European countries, the Finnish percentage is lower than the EU average in the science and engineering sectors. Why is the country's percentage of women scientists and engineers still low? A possible explanation is the gender-equality paradox found in the research findings by two universities in England and the United States that countries with high gender equality tend to score low in women's STEM participation. According to this study, there are wider economic factors at work which lower women's STEM participation. If women worry less about economic issues or if there is greater gender equality in a country where they live, gender gaps in academic benefits and career interests have much influence on women's university and career choice.

As a result, the EU has a higher percentage of women in the engineering sector, compared to North America. Especially, the developed countries, including Germany, support female engineering students to enter the engineering sector by developing their career paths and building a database of female engineering professionals. However, most of the European countries have not yet reached 50% in women's STEM participation in spite of steady progress made for the past 12 years. And women scientists and engineers are still underrepresented in the engineering sector such as manufacturing (21%).

2.2. Domestic gender gap

Let us now look at the domestic gender gap. As of 2019, there were 71,784 female natural engineering majors, and among them 34,284 were life science majors and 37,500 were engineering majors (WISET, 2021). When looking at the trend since 2011, the number of natural science majors used to be higher than the number of engineering majors but starting from 2017 the number of engineering majors began to exceed the number of natural science majors. Among engineering freshmen, the percentage of female students was 21% in 2019, which was an improvement of

2.7%p from the 2011 level. However, it still falls short of the number of female natural science freshmen which is 51% of the total freshmen. Even as the number of female engineering freshmen increases every year, the ratio of engineering majors to the total female student population is still low at 11.3%. In other words, 1 out of 10 female students is an engineering major. On the other hand, 39.9% of the male student population are engineering majors while a half (49.9%) of them are majoring in science and engineering.

The gender ratio of engineering students is shown in Fig. 3. In 2010, males accounted for 82.3% while females made up for 17.7%. Though the gender gap is gradually narrowing, 77.7% were males while 22.3% were females in 2019, with the gender gap reduction of 9.2%. With an increased ratio of female engineering students, the gender gap is narrowing but the support system that leads them to participate in their major areas still seems inadequate.

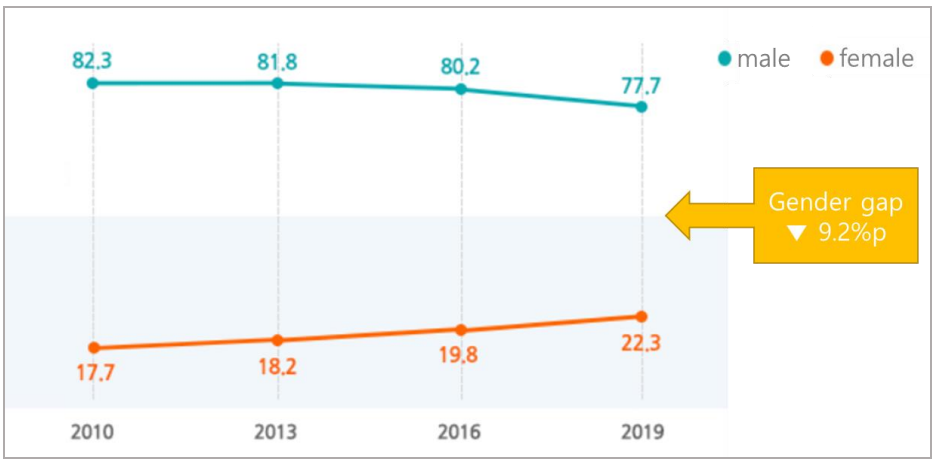

Fig. 3: Gender gap in engineering

To this end, the Ministry of Education launched the Women in Engineering - Undergraduate Leading Program (WE-UP) in 2016 (Korea Ministry of Education, 2016). About ten universities selected for the program focused on i) improving their curricula tailored to social demand, ii) supporting the career, employment, and start-up plan of female engineers and iii) enhancing the culture of engineering education to be woman friendly. First, for the curriculum improvement tailored to social demand, promising career fields for female students were analyzed while taking into consideration of a long-term resource supply and demand forecast, and customized multidisciplinary curricula were provided per academic year. Also, customized major tracks to absorb a new demand were created to provide major studies necessary to start a career in promising engineering sectors, along with liberal arts courses. In addition, more opportunities for customized on-site field

practice and participation in research projects were offered to female engineering majors in partnership with industries to help them better adapt to the field. Second, the support for career, employment and start-up plans was offered in consideration of women's life cycle. Moreover to develop the leadership of female engineering graduates, a curriculum was designed together with a mentoring program. And career maps and guidance were provided after analyzing the career paths of female engineering graduates. Last but not least was making the engineering education culture to be woman friendly. To improve the engineering education culture and environment to be woman friendly one should understand there need to be teaching methodologies tailored to female engineering students and those methodologies need to be shared. Moreover, efforts should be made to improve the male-centered perception and culture through gender equality education.

The gender gap in engineering shown so far is prevalent across the globe. As such, countries around the world suffer a lack of female engineering talents and are making diverse effort to address this issue. This study as well has been conducted as part of an effort to support female engineering talents. Particularly, it aims to propose a platform that helps design a lifelong career, employment and start-up plan of female engineering talent.

3. The proposed career management platform

3.1. Overview of the proposed platform

According to a recent study conducted by Jang (2021), a career management platform is developed to strengthen the career competencies of female engineering students and to validate its educational efficacy. This career management platform is based on role model portfolios in order to reinforce the career competencies of female engineering talents and effectively manage their employment quality. The portfolios are being used on campus as one of the tools to manage students' learning process and career. Career portfolios, in particular as a tool to support students to actively explore their career paths in their chosen fields, verifies students' knowledge, competencies (skill set) and attitudes on career design, and it is made of a comprehensive collection of students' self-evaluations and evaluators' comments. As such, the career portfolios are a useful tool for personal growth and development with introspection and reflection as students accumulate their experience of career activities and organize the process.

Upon entering an engineering college, students search role models and set them as career goals on the platform, introspect their growth process and check achievement against it systemically while accumulating and organizing experiences of activities aimed to achieve their career goals. The brief description of this platform is shown in Figure 4.

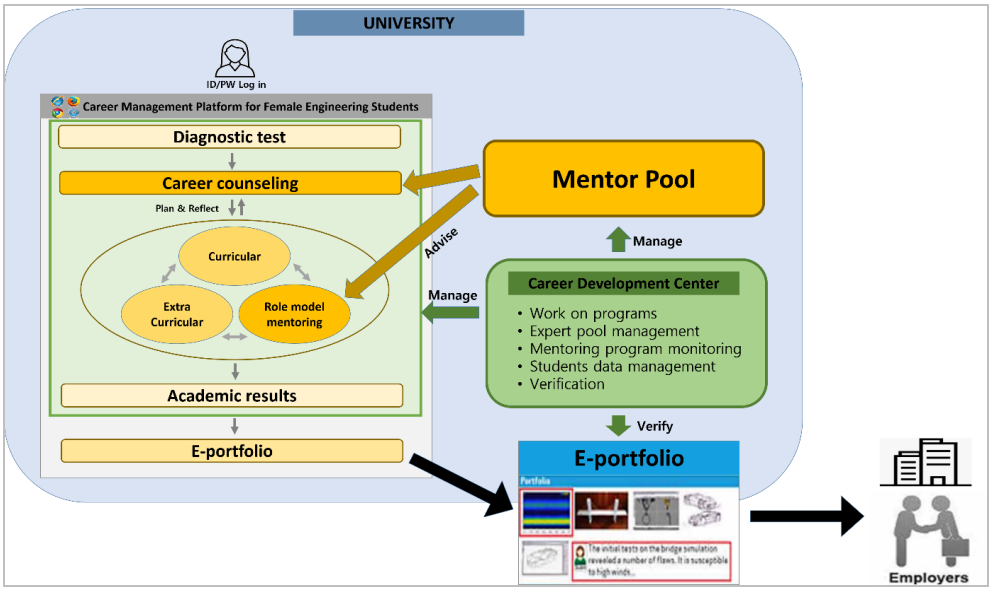

Fig. 4: Career management platform for female engineering students

From Figure 4, one can easily understand how a female engineering student on the career management platform gets to start a career. When the female engineering student logs in on a web-based career management platform, she first takes an aptitude test. A university's career development center recommends mentors with similar majors, based on the diagnostic test results so that the students can receive career counseling. The recommended mentors compare and guide programs that can help reinforce training and career competencies necessary to start a career in her major field. Moreover, the platform guides the student to be mentored by connecting her to her role models who are already working in the field where she aspires to enter. All the university activities are stored in an e-portfolio and the university's career development center verifies the e-portfolio. All female engineering students who look for a job can apply to the companies of their choice just with the e-portfolio, without having to prepare separate documentation. Furthermore, industries can easily hire talents from the e-portfolios of female engineering students.

3.2. Use scenarios of the career management platform for female engineering students

The following scenarios help understand how female engineering students use the career management platform. A female engineering graduate who used the platform is named "Jiyoung". She joined a college of engineering as a materials science and engineering major. Then, she realized that she had little understanding of the college as she started taking her major courses. So, she wanted to get some counseling but there was nobody she could ask for help. Because most of the people

around her were either male upper classmates or male professors. In the end, she decided to use the career management platform recommended by the university.

The platform guided her to take an online career psychology test in order to first understand her aptitude and interest. The test showed that she was apt to study engineering and professions such as professional researchers, university professors and science teachers would be good fits for her. Based on the test results, the university connected her to three female engineers as her mentors who were working in the field. From the mentoring, she was able to get information needed for her future university studies and to explore career. Mentor 1 who was a professional researcher introduced her the current trend and future prospect of display manufacturing process which is the latest technology. She advised on the curricula and competencies needed to start a career in the given field. Mentor 2 who was a university professor researching in Nano technology shared the world of Nano technology, needed career competencies, and her own experiences. Lastly, Mentor 3 who was a science teacher advised her to take courses by dividing time between major courses and teacher training courses. Moreover, she told her hands-on experience of working as a science teacher. From the three mentors, Jiyoung realized that research was something she truly wanted to do. So, she decided to become a display technology researcher and reorganized her major program with courses related to display technology. Moreover, she compared and participated in different projects to gain research experience. She took part in a few research projects as part of a team with students from other universities, and once worked in a college professor's office as a research assistant. Throughout four university years, she was able to shape her dream by engaging in various activities related to her career. In addition, from the meetings with female display technology researchers in their 20s, 30s, 40s, and 50s she was able to design her own future. Through it all, she realized that she would have different concerns and solutions as per different stages of her life as a woman. All her university activities related to career development were recorded in her e-portfolio. And she could successfully start a career in display technology by submitting her e-portfolio to relevant companies.

3.3. Limitations of the proposed platform

The career management platform introduced above provides students various information to introspect the process of becoming a professional by going through their own university activities. As such, students are guided to plan their own learning through self-directed university activities and by exploring careers after graduation. In addition, the platform supports the administration of students' activities designed to achieve their career goals, and all activities related to career and employment during the university years are entered into the system which reduces any additional administrative work. However, this platform presents a few limitations to be a lifelong career management system that helps female students

after graduation and throughout their life.

Limitation 1: The existing career management platforms are managed by universities which students belong to. Therefore, they only record students' activities during the university years. Moreover, it is the university career management center that operates the platform, manages mentors and reinforces the career and employment competencies of the students by comparing curricula and career development programs. And the role model mentoring which is specific to the platform informs the students of jobs they aspire to take. However, there is only as much that few resources at the career development center can do. Hence, it is particularly difficult to provide services customized to the aptitudes of individual students. This shows how urgent it is to build an integrated platform in order to overcome the existing limitations and to manage students' post-graduation career and employment.

Limitation 2: All the activities done during the university years can be verified by the university. However, since it is done by people, there can be errors and omissions. In other words, the platform administrators can correct them anytime. And of course, student may also make mistakes when entering their activities on the platform. For example, even if a student enters one year in the research participation period when in fact, she was with a research project for a month, the platform administrator cannot verify it. The reliability of data cannot be guaranteed if this is the case. In addition, there is still a limitation that the university cannot manage the post-graduation activities and history of a student. When a female engineering student starts a career and accumulates experience as an engineer after graduation, she must contact relevant institutions individually for reference check. Especially, old records are likely to be damaged and data can be forged. Hence in order to manage the records of female engineers accurately, their records should never be forged. And to guarantee the reliability of data, there should be solid proof to verify it. Because there are verified records, students can be given reemployment opportunities.

Limitation 3: The existing platform above is a web-based service. Though it has the benefit of being able to be accessed and used anywhere on a web browser, it has an inherent limitation of keeping students' records during the university years only. Also, it has security vulnerabilities and is exposed to hacking risks since the university manages students' entire data on the platform. If the university's security system is hacked and hence compromised, students can lose all their precious data. In other words, all the activities they did during the university years can vanish in a second. Moreover, a lot of personal information inside e-portfolios would be leaked, creating innocent victims. When the system is hacked, data gets damaged. As such, there should be protections put in place in order to complement it.

4. Reframing the current career management platform using AI, big data, and blockchain technology

As has been mentioned in Chapter 3, the limitations of the existing platforms for female engineering students can be fully overcome with adoption of the latest technologies of the fourth industrial revolution. By adopting AI, big data and blockchain technologies in particular, the limitations of the existing career management platforms can be overcome, and a lifelong career management platform can be created to support female engineering students as well as female engineers. Chapter 4 shows how the adoption of such new technologies can transform the existing career management platforms.

AI and big data: How can AI and big data technologies be utilized for a career management platform? Recently, there have been many career management platforms developed to connect female engineering students to mentors, by understanding their characteristics and career directions while relying on human experience. Since it is done by human, it is not easy to manage a vast amount of data. Furthermore, there are only few resources to provide customized services to all individual female engineering students. However, with the adoption of artificial intelligence and big data technologies the existing limitations can be overcome. These technologies enable easy collection, storage, and analysis of different data. Then, the platform analyzes a vast amount of data on the aptitudes and careers of female engineers and compiles it into a visualized report for an easy understanding of certain areas. In addition, big data collects the information of mentors and mentees and analyzes it to provide new services necessary for female engineers.

Artificial intelligence technology can be used in a customized matching system. The AI technology is very effective in drawing a conclusion in real time to get an optimal result after understanding the current conditions and competencies of individual female engineers. As per the personal interests and levels of understanding among female engineers, it intelligently recommends mentors and helps the users' gradual improvement. Moreover, artificial intelligence analyzes the information, including data collection, case analysis and visualization, of female engineers, and allows them to spend more time in high-level thought, real & virtual experience, and interactions with other female engineers. Also, the existing issue with a matching system which relies on the experience of platform administrators can be offset with the technology effectively managing administrative work and time. Therefore, with the introduction of big data and artificial intelligence technologies, a customized mentor-mentee matching system can be created to improve the competencies and interest of female engineers.

Distributed ledgers and blockchain: Blockchain is a distributed ledger system which is decentralized based on absolute security and trust. A transaction is time stamped, encrypted and recorded publicly while being placed with a single-use

stamp and connected to the previous transactions. Such digital block is updated only if there is an agreement from all the stakeholders, hence it is impossible to intercept, correct and delete data. Blockchain has the potential to improve all areas of the platform, such as blocking DDoS attacks by enhancing data integrity, digital identification, and the security IoT devices. In fact, blockchain provides better flexibility, encryption, inspection, and transparency, including the CIA triad, namely: confidentiality, integrity, and availability (Kim, 2018). Therefore, the issue of data integrity and security in the existing system can be adequately addressed with the introduction of blockchain technology.

Customized service system powered by AI and big data: In order to nurture female engineers and prevent a talent loss, it is critical to introduce a customized service system where the latest technologies such as big data and artificial intelligence are put to use. This is because it can make recommendations by connecting a new female engineer to mentors from a talent pool it manages, taking into consideration of her lifecycle stage. On this customized service system individual female engineers record their own information and history and manage them as a database. And on the platform, the female engineers are able to create communities with people who work in similar fields.

In addition, the new platform makes resource management per field easier. At a time when talent development of female engineers is becoming critical, the platform can become a sustainable system where not only career-related activities during the university years but also every post-graduation activity are managed. Especially, women's engineering career can be curtailed due to different life events and female engineers may experience career interruption. To name a few, childbirth and care are some of the examples. Since the existing platforms are only available to university students, it is quite easy to overlook this aspect. And this is something the university students have not yet experienced. Once they leave university, there aren't many people who would hear their concerns about career interruption. Hence, it is important to form a community with people who either are having the same concerns or have already resolved them. On the new platform, they will be able to share their own experience of how they resolved such concern and furthermore get advice on how to start a career in the related fields.

Moreover, new female engineers can get help in solving issues and planning future steps by meetings with many seasoned female engineers. In other words, with the introduction of artificial intelligence they will be able to choose, based on their selected criteria, either a young female mentor who is in their age group and similar circumstances or an old female mentor who is recommended by the system and working as a professional in the field similar to theirs. And they will be able to design a lifelong career and experience by learning about the life and experience of their recommended mentors, sharing their issues and getting advice on solutions. This is a way to overcome the limitations of the existing platforms as described in

'Limitation 1' above and to manage the female engineering talent in a sustainable way. Engineering technology advances and changes in a rapid pace. As such, the related careers come and go or advance with change of time. On this platform, one's career path can be modified or complemented whenever there is change. Also, whenever the path changes, new mentors are recommended, based on the changed path, which is a plus.

Therefore, it is urgent to introduce a sustainable career management platform to prevent a female engineering talent loss and help female engineers to minimize gaps in their careers after graduation.

Blockchain-based decentralized system: In order to be able to manage female engineering talents and connect them to one another, personal history and information should be accurate. Since this system handles a lot of personal information, all information must be encrypted. Data should be encrypted and the storage space needs to be divided among different users, so when a file is copied, the risk of personal information leakage and hacking can be minimized.

In addition, decentralized, distributed cloud or distributed storage technology can be used to reduce the cost of data management and any additional administrative work. With the adoption of blockchain technology, data reliability and hacking risk which are the limitations described in 'Limitation 2' and 'Limitation 3' can be addressed. For the mentor matching to be a special feature on this platform, information of individual professionals must be accurate and trustworthy. And female engineers registered on this platform should enter their accurate information and be able to verify it. As such, blockchain technology should be utilized for information accuracy and reliability. Moreover, because users are connected to professionals via the online system, a minimum number of system management resources is required while offsetting or reducing any concerns about administrative mistakes or information corruption.

In conclusion, Fig. 5 below is a user-centered career management platform empowered by the new technologies (artificial intelligence, big data, blockchain) proposed by this study.

The user-centered career management platform empowered by artificial intelligence has a benefit of managing all female engineers scattered across different platforms in a single platform. The platform can analyze the information of registered female engineers to recommend professionals, by understanding the current number of female engineers, numbers of female engineers per field and their age and place of residence.

Female engineers enter their personal information on the platform to get mentor recommendations that match their specialized field. They can either develop their career as per the advice of a recommended mentor or share and ease their concerns through meetings with mentors. Moreover, at professional communities they can get introduced to mentors of different age groups and introspect their own

lives by learning about the mentors' lives. In particular, this platform prevents a loss of engineering talents and greatly promote the career development of female engineers.

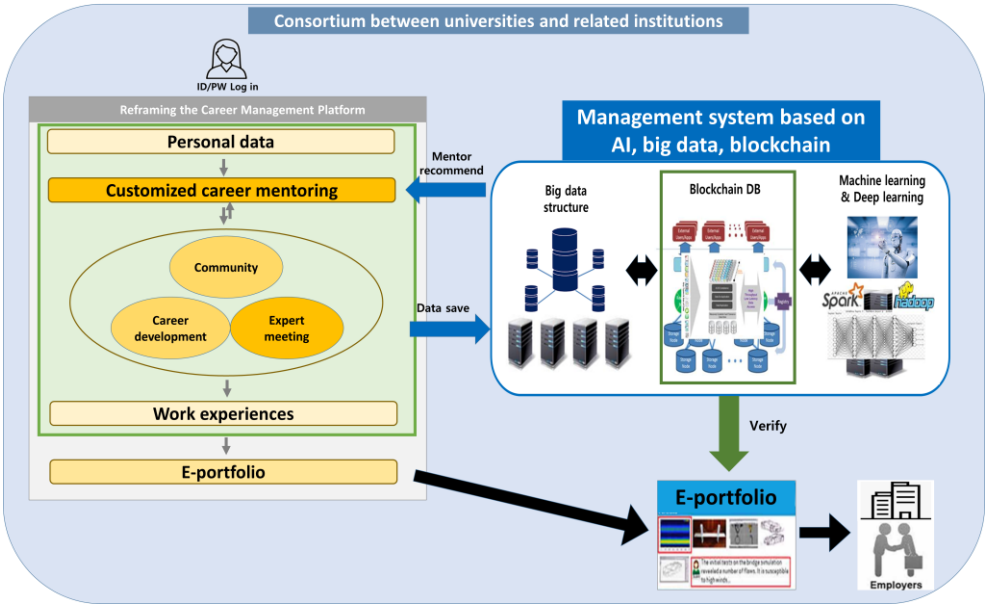

Fig. 5: User-customized career management platform empowered by AI, big data and blockchain technologies

5. Conclusion

Gender gaps in the engineering sector are the common phenomenon across the world, with no exception for the Republic of Korea. Countries across the world have been investing a lot of resources in promoting and supporting female engineers. Though career management platforms for female engineering students which were developed as part of promoting female engineers have many benefits, yet they inherently face a few limitations. First is the limitation to provide customized services. Second is the limitation to guarantee the reliability of data. Finally, it is the limitation of data hacking risks. This study proposes ways to expand the existing platforms while complementing their issues. In conjunction with artificial intelligence, big data and blockchain technologies which are the new technologies of the fourth industrial revolution, a new platform has been proposed which is open to all female engineers and where operations are sustainable.

However, there are some people who do not look kindly on the state subsidy to promote female engineering talents. Given the engineering sector environment and its demand for creative talents, they think it is reverse discrimination to address the issue of female engineering talent promotion alone. At a time when engineering

talents can determine a country's international competitiveness, I agree that engineering talents of both genders should be promoted, not as part of affirmative actions but as an effort to realize social justice and make social contribution in engineering. However, as has been proposed in this paper, though a lot of investment has been made in promoting female engineers, yet there is a disproportionately large loss of female talents, which could possibly turn into a loss for the country. Hence, in order to reduce a loss on investment and increase the national competitiveness, there should be sustainable management of female engineers. And at a time when the labor market participation ratio of female engineers can determine a country's international competitiveness, there has to be diversified research into the career management of female engineering talents from different angles.

Acknowledgements

This work was supported by National Research Foundation of Korea (NRF) grant funded by the Korea government (No. NRF 2018R1C1B6008390 & NRF 2020R1G1A1100739).

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