An Implementation of Computer Simulation-based Smart Learning System for Higher Education: EDISON

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Abstract

Many people from various sectors are now talking about the "Smart" things such as devices for work, home, education, and so on. Smart is another word for intelligence. Smart learning can be defined as a quite innovative way of getting the knowledge, especially in advanced science and technologies. Smart learning environments are always connected with WiFi, 3G and 4G and provide a learners' paradise where they can learn anywhere and anytime whatever they want to learn.

In this paper, we have developed a computer simulation-based smart learning system called EDISON (EDucation-research Integration through Simulation On the Net) for supporting the area of CFD (Computational Fluid Dynamics). The EDISON system could be used by the curious learner, much like Thomas Alva Edison who lived in the 19th century and liked to do all kinds of experiments to verify or discover answers to his curiosities or to solve problems. We who are living in the 21st smart century can do many experiments like those done by Edison through computer simulations in a smart learning environment using EDISON. In addition, we explain in detail how we have been motivated to develop the EDISON system, what kind of functionalities and architecture it has, how the system is serviced, and how we plan to expand our system in the future.

Keywords: *Smart Learning, Computer Simulation, Higher Education, Edison*

1. Introduction

The IT revolution represented by the Internet that emerged in the late 20th century is incredibly expanding its power with the "Smart things" [1]. Many people from various sectors are now talking about the "Smart" things such as devices for work, home, education, and so on. Smart is another word for intelligence. Smart learning can be defined as a quite innovative way of getting the knowledge, especially in advanced science and technologies. Smart learning environments are always connected with WiFi, 3G and 4G and provide a learners' paradise where they can learn anywhere and anytime whatever they want to learn.

This paradigm is rapidly changing people's daily learning. The developed countries such as the US and the EU have tried to apply the research accomplishments of advanced science and engineering technology to realize the paradigm especially in higher education to strengthen students' competitiveness in science and engineering technology. To this end, those countries operate a nanoHUB project for the education of nano technology in the US [2]. There are also the ICLCS (Institute for Chemistry

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Literacy and Computational Science) project for the education of Chemistry [3], the ICEAGE (International Collaboration to Extend and Advance Grid Education) project for the education of grid computing technology [4], and so on. The Korean government has also started to fund a project to build and provide a computer simulation-based smart learning environment for college students in science and engineering fields from 2011.

In this paper, we have developed a computer simulation-based smart learning system called EDISON (EDucation-research Integration through Simulation On the Net) for supporting the area of CFD (Computational Fluid Dynamics). The EDISON system could be used by the curious learner much like Thomas Alva Edison who lived in the 19th century and liked to do all kinds of experiments to verify or discover answers to his curiosities or to solve problems. We who are living in the 21st "smart century" can do many experiments like those done by Edison through computer simulations in a smart learning environment using EDISON with small experimental cost and less danger. In addition, we explain in detail how we have been motivated to develop the EDISON system, what kind of functionalities and architecture it has and how the system is serviced and how we plan to expand our system in the future.

2. Related Studies

There have been a number of simulation-based learning systems developed such as nanoHUB, ICLCS, ICEAGE, e-Fluids, Java Applets for Science and Engineering Education, and so on [2, 3, 4, 5, 6]. The most widely used system is nanoHUB which was initially developed for users of nano science technology. This project has been supported by the US National Science Foundation from 1995. Currently more than 200,000 users from 172 countries are learning nano technologies by running their simulations using many simulation tools and various digital contents developed and uploaded by nano scientists on the nanoHUB site, http://hanohub.org/. One thing we should be concerned about is that the number of nanoHUB users from the top 50 US engineering schools is dramatically increasing and many published SCI (Science Citation Index) level papers are cited more than 500 times. Furthermore, the platform for the nanoHUB project had been released as an open source package known as the HUBzero platform for scientific collaboration [2]. This platform has been used to create more than 30 other hubs covering a wide variety of disciplines, including cancer care, pharmaceuticals, environmental modeling, biofuels, and even volcano research, to name a few.

There are number of researchers who have realized the importance of developing and provisioning a smart learning system especially for higher education in the fields of Science and Engineering in Korea. However, only a few free smart learning systems like e-AIRS (e-Science Aerospace Integrated Research System) for the area of thermal and fluid dynamics have been developed and serviced [7]. This system is quite useful in the classroom, but it has number of limitations in functionalities and stabilities. This means it hasn't got any global competitiveness and scalabilities to expand to other areas.

Therefore, with the experience from the development of e-AIRS, we are going to design an easily scalable architecture and develop an open platform that could be easily expanded to other areas - like the HUBZero platform derived from the nanoHUB project - through the EDISON system.

3. Necessity of Smart Learning Systems

In recent years, the Korean government has put a lot of R&D funds for enhancing national competitive power into science and engineering technology. All in all, the ultimate goal of all these efforts is to become the 10th most advanced country in the world in terms of basic and core technology developments in the near future [8]. As the amount of investment in national R&D projects increased, the research accomplishments have dramatically increased: The number of Korean SCI papers ranked in the 18th in the world, and the number of registered international patents placed 3rd followed by Japan and the US. Using the research accomplishments of science and engineering technology significantly affects the continuous development of the overall society in economy, culture, education, and so on.

The Korean government has also been developing various methods for enhancing the ability of learning and teaching that can increase students' interest and make them willingly study science and engineering technology. One of the attempts is by means of building a smart learning environment based on recent advanced research accomplishments that have not been tried to be used in higher education. From the report of IMD (International Institute for Management Development), the usefulness of the national higher education system in Korea was very poor and that could be very closely related to the quality of new graduates majoring in science and engineering fields [9]. According to the other report by the Korea Employers Federation in 2008 [10], people who haven't got much experience with real workplaces need to be reeducated at least for 19.5 months with the minimum expense of 2.3 trillion won (2 billion dollars). The gap between the actual ability of graduates and the required ability in the workplace has to be decreased to achieve global competitiveness. The most serious problem of this situation is that we will not be able to lead or even keep our current status of competitiveness in science and engineering technology without providing experiments or simulation-oriented education services for cultivating human resources of high quality [11, 12, 13, 14].

In this paper, we have investigated the current status of Korea's R&D activities and higher education especially in the science and engineering areas in order to find out possible ways of maximizing the synergy effect between them. To do this, we surveyed 822 people including professors, researchers, students and workers in the relevant industry. According to the survey, 773 respondents (94%) out of total 822 respondents answered that the higher education environment for science and engineering in Korea should be improved.

With respect to the research methodologies used for their researches by the respondents in the professor group, 103 professors (44%) said they are using computational (simulation) based experiments (see Figure 1). Note that higher level researchers like professors carry out their researches by computer simulations. This trend is getting stronger than ever before because of the high performance of computing facilities and smart environments provided around us.

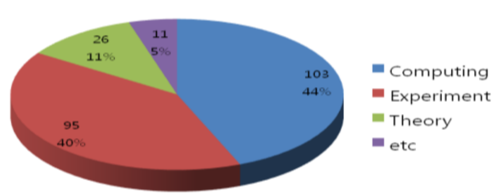

Figure 1. Methodologies used for research (Professor group)

In particular, half of the respondents highly agreed with the necessity of strengthening students to understand the basic principles of the curriculum subjects with the help of some kinds of visible tools (see Figure 2). The professor group has also highly agreed to the necessity of developing curriculums associated with real working place related projects for giving students a chance to solve actual problems. About 75% of respondents highly and generally agreed to the 10 improvement suggestions listed in the questionnaire. The list of 10 possible improvement suggestions was as follows:

A: Understand the basic principles of science and engineering technology
B: Improve the theory based teaching methodologies
C: Reflect recent research trends and accomplishments in the curriculum
D: Teach students with actual problems and cases
E: Provide various teaching contents with a sense of realism for higher education
F: Strengthen professors' continuous innovation efforts in teaching methodologies
G: Stimulate and expand the exchange opportunities among the universities, research institutes and industries
H: Teach students with science and engineering tools and software required in the workplaces
I: Perform various projects in the classroom to solve actual problems that will be faced in the workplace
J: Continuous support to build the cooperative environment for the higher education and research on the governmental level (see Figure 2)

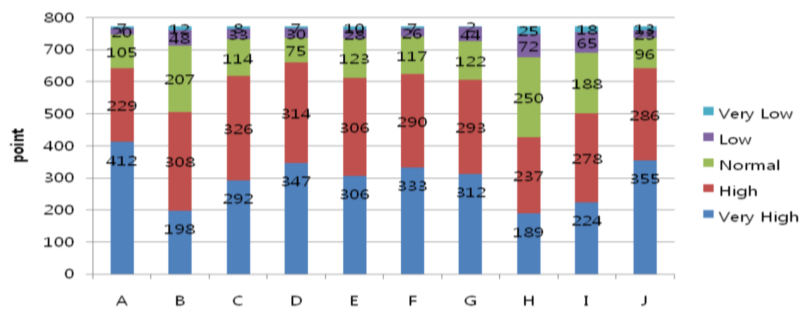

Figure 2. Agreement level of improving the higher education environment

For the question "If a computer simulation-based smart learning system for the science and engineering is developed and provided, are you willing to use it in your classroom?", 87% of respondents said 'Yes' (see Figure 3). The reason to use the smart learning system is that they can teach difficult theories in an easy and simple manner and it is easy to stimulate student's interests.

For the final question "If the smart learning system for the science and engineering higher education and research is developed, in which science and engineering fields will it be the most effective?", the respondents said that the most effective fields would be bio-technology (27%, chemistry, biology, etc), nano-technology (21%, physics, materials science engineering, etc.), information technology (21%, computer, information and telecommunication, etc.), and space technology (16%, machines, aerospace, etc.). According to the users' demand, we will expand our service areas of the smart leaning system (see Figure 4).

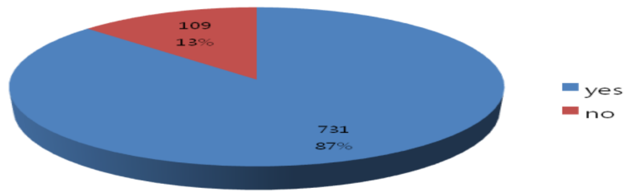

Figure 3. Willingness of using a smart learning system

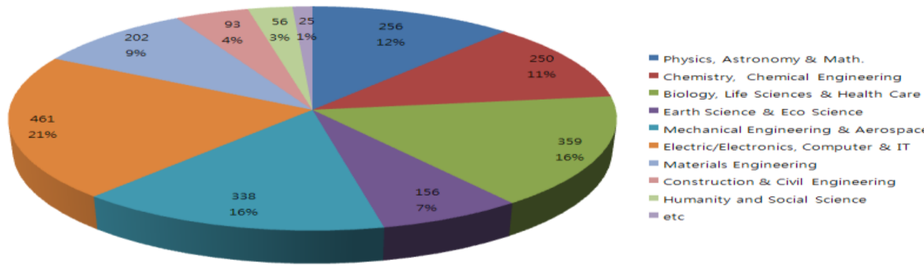

Figure 4. Effective areas of smart learning system

4. A smart learning system: EDISON

Referring to the statistics with respect to the departments and the number of registered students in college in 2009, the numbers of students registered especially in the engineering and the science and technology category were 95,788 and 22,196, respectively. From this, we can easily estimate the possible users of the smart learning system [8]. To accommodate those possible users of the smart learning system, we have designed and implemented a computer simulation-based smart learning system called EDISON. This system can definitely change the paradigm of existing science and engineering technology education in Korea.

Development of simulation related technology can also definitely eliminate the boundary between the real and the virtual world. It is expected that more and more digital books, contents and simulation software for education will be widely used and will have a great effect on many areas. Computer simulation-based smart learning systems could be an effective way of virtual experimental learning by means of knowledge transfer and sharing with the aid of advanced information technologies and cyber infrastructure. The derived requirements found by investigating the other similar systems like nanoHUB and suveying the expected users are as follows:

- Provide highly user-friendly environment: simple and easy interface to run simulation and check results for beginners
- Construct open environment and free to use various high quality simulation software and contents
- Construct interactive systems in which both students and tutors can actively participate
- Construct sustainable user support and maintenance system
- Develop public relations and community programs

The general system architecture of EDISON is in Figure 5. We have tried to accommodate all the mentioned above requirements. The EDISON system consists of (1) the Science-AppStore (Science-AppStore is a similar concept of Apple's AppStore, but it is a kind of storage for scientific applications such as simulation tools, software, contents, and so on are easily up/downloaded. See Figure 6) for managing simulation tools and analyzing all the program information, (2) the PSE (Problem Solving Environment) in which users can carry out their simulation easily in this environment, (3) the cyber infrastructure which provides all the necessary services to run the simulation by using (4) various computing resources which comprises supercomputers, high performance networks, large storages, and so on in the PSE. The major technologies used for developing the EDISON system are the high performance computing middleware technology, virtualization technology, open API platform technology, contents management system (Joomla) technology, web visualization technology for the pre and post processing, and so on.

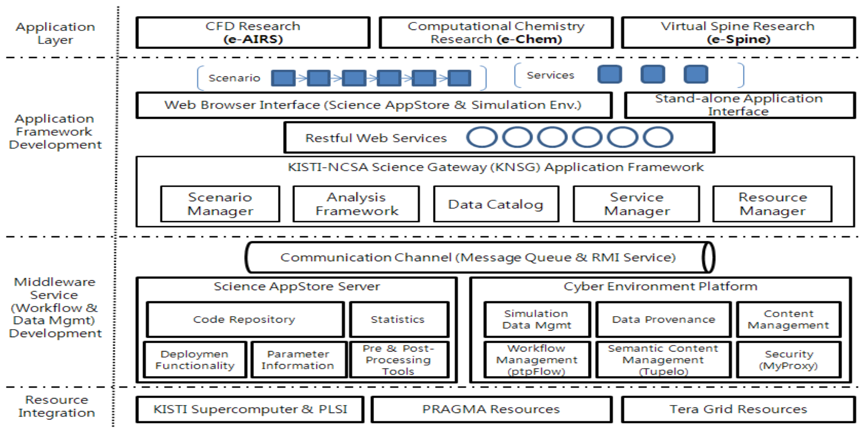

Figure 5. System architecture of EDISON

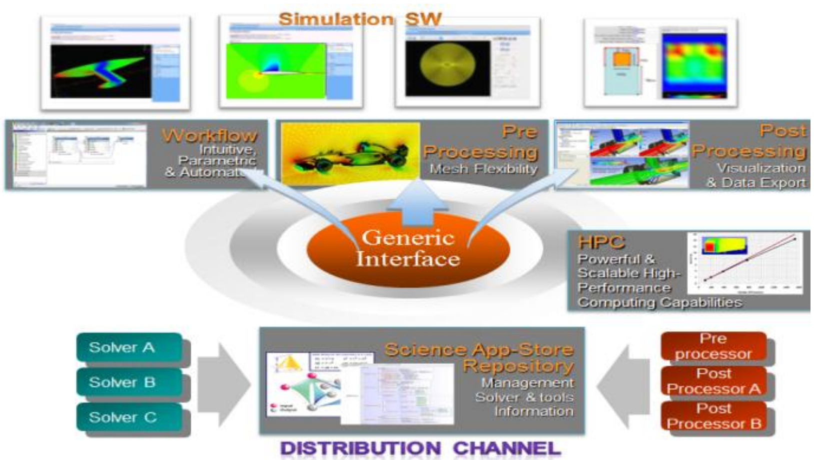

Figure 6. Concept of Science-AppStore

Figure 7 shows some steps of running a simulation on the EDISON system. Users on the Internet called the 21st century EDISON in the area of CFD can run their experiments by taking the easy steps on http://www.edison.re.kr/. Our initial EDISON system has been used by 671 users from 14 colleges in Korea so far. User evaluation of the EDISON system is very positive. They think the system is very useful and helpful to understand difficult theories in an easy manner. They also want to keep using this system later on. The EDISON system will add more functionalities for better supporting users in CFD areas and will be deployed to other communities such as computational chemistry, nano physics, and so on.

Figure 7. Steps of running simulation on EDISON (Pre-process -> Run -> Post-process)

5. Conclusions

The IT revolution which emerged in the late 20th century is getting more and more popular and such a quick propagation has a great effect on the growing new smart generation. If the advanced accomplishments obtained from R&D projects could be used in science and engineering education through the means of computer simulation, the effect in science and engineering education would be maximized without extra spending for purchasing expensive educational software developed by and imported from other countries.

Thanks to these revolutionary technologies, we could develop and provide the smart learning system, EDISON, which is a computer simulation-based learning system for the virtual experiments. Providing the smart learning system to the higher education can definitely enhance the competitive power of Korea by cultivating and providing the high quality human resources to the required workplaces. The EDISON system with domain specific functionalities will be developed and deployed in a few other areas in the near future.

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