International Graduate Program on Quantum Engineering Design: Towards Realizing Borderless Education Through Partnership and Collaboration

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Abstract

To prepare the students for operating in a “global” society, and make “internationalism” an essential component of daily life, we need to promote a mode of study that involves: (1) Opportunities to mix with classmates from a wide variety of national or cultural backgrounds; (2) Daily use of more than one language; (3) A curriculum that gives insight into how to examine society (and oneself) from various angles; and (4) A curriculum that develops awareness of the problems society faces, and equips students to tackle the problems rationally and confidently. With the establishment of an International Graduate Program on Quantum Engineering Design, we set out to achieve these goals through partnership and collaboration. Hopefully, experiences gained from these exchange programs would equipped the students to become better leaders who welcome challenges and challenge the status quo, and perhaps even realize a true Borderless Education, based on knowledge networks.

Keywords: Brain Circulation, Knowledge Network, Borderless Education, Partnership, Collaboration

1. Pie in the Sky: Knowledge-Based Society, A Dream Community

What determines the Dynamics of the Global Economy? What are the pressing problems of the Global Economy? Regardless of sector, we can immediately agree on two classic factors/problems, viz. Uneven Distribution of Wealth/Resources and Loss of Knowledge (Brain Drain). How do we propose to solve these? One way is to shift to a KNOWLEDGE-based society (as opposed to an information-based society). A society that promotes brain circulation, not brain drain. A society that guarantees the same level of safety and security (both of mind and body) to each society member and ensures correct level of harmony with nature. A society that ensures that posterity would be provided with a progressively better environment.

The concept is not new. It has been introduced before in the context of conceptualizing the future of Asia [1,2]. In this future society, we can envision a Dream Community that is tolerant and open towards others. A community that, when faced with multiple challenges, takes it collective wisdom, and forges ahead to find solution at any and every opportunity. A community where the people reach out to others and collectively share experiences. A community that holds no distinctions over what might be considered superior or inferior. A community that fosters exchange and understanding between future government leaders, industrialists, tycoons, academic and scientific leaders. Needless to say, the last points to our students and the importance of what kind of education we can provide.

2. Quantum Engineering Design Research Initiative (QEDRI) [3,4]: Laying the Foundations

In the pursuit of academic excellence, world cooperation, and the Osaka university motto “Live Locally, Grow Globally”, apart from carrying out international collaborative researches, the academic exchange of researchers, we also need to broaden the students’ awareness of the complex issues surrounding this new international/global era in which we live, perfect their language skills, and gain knowledge of the political, social, and economic issues that world faces today. Furthermore, we need to provide first-hand experiences that would equip the students to become better leaders who welcome challenges and challenge the status quo.

To prepare the students for operating in a “global” society, and make “internationalism” an essential component of daily life, we need to actively promote a mode of study that involves:
- The opportunity to mix inside and outside class with classmates from as wide a variety as possible of national or cultural backgrounds;
- Daily use of more than one language;
- A curriculum that gives insight into how to examine society (and oneself) from various angles; and
- A curriculum that develops awareness of the problems society faces, and equips students to tackle the problems rationally and confidently.
Quantum Engineering Design Research Initiative (QEDRI) [3, 4] was established in January 2006 to promote Osaka University Graduate School of Engineering as one of the “World Premiere Research Centers” under the leadership of the incumbent dean [5–7]. It involves research in various fields (Physics, Chemistry, Mathematics, and Information & Computer Science), interdisciplinary in nature. Its mission is to carry out researches that would effectively meet the ever-changing needs of the Society, e.g., the design of novel materials, highly sophisticated and functional devices, as well as environment-friendly technology, through the development of novel theoretical routines and techniques. It relies heavily on close collaboration, not only among the 6 academic/research divisions and 11 departments, but also close collaboration with industry, government agencies, universities/institutes in Japan and other countries. All of these form a closely knit QEDRI network of academia, industry, and government agencies, both domestic and foreign. In 2014 [3], the QEDRI set out to create a network of integrated “global campus” for the promotion of international collaboration and development of human resources through research and educational programs, in addition to the above-mentioned missions.

The QEDRI research area is composed of three core divisions, with the following corresponding research thrusts:

- **1st Core: Creation of Frontier Mathematical Methods [8]**- Aims to build mathematical models based on computational mathematics, computational physics, and computational chemistry to capture a unified view of self-organization, and gain relevant information from the model created.
  - Development of quantum simulation and first-principles calculation methods;
  - Development of simulations techniques incorporating the hyper multi degrees of freedom involved in complex phenomena;
  - Development of analytic techniques for determining physical properties and tracking dynamical phenomena; and
  - Development of micro-macro coupling analytic techniques.

- **2nd CORE: Elucidation of Emergent Material Function [9]**- Aims to develop quantum simulation into the standard theory/model for materials science. Carry out quantum simulation-based studies on the elucidation of quantum reactions, material function, and expression mechanism for particular nano-scale structures. Researches include
  - Design and functional elucidation of novel reactions based on atomically/molecularly state-resolved control and manipulation techniques;
  - Design and functional elucidation of novel materials, e.g., carbon-based magnetic material, spin electronics material, correlated materials; and

- **3rd CORE: Realization of New/Next Generation Functional Materials [10]**- Aims to accelerate research and development of materials and realize industrial applications based on integrated design concepts and techniques. Carry out research, design and realization novel functional materials for safety and security purposes, as well as maintain a high well-being. These include the the construction of high-speed, secure communication systems, environment-friendly, renewable devices, etc. Researches include
  - Damage evaluation of composite materials based on experimental methods and simulations;
  - Design and realization of environment-friendly materials, high-efficiency energy conversion materials, bio-compatible materials, sensor materials for safety and security purposes; and
  - Design and realization of novel functional materials based on the ability to control the atomic/molecular-scale structure using a combination of techniques from nuclear fusion, reactive plasma and charge particle beams; and
  - Application of advanced plasma science to space engineering.

This initiative laid the foundations (through the network of people, expertise, and other stake holders) for what would be called the Quantum Engineering Design Course.

### 3. Quantum Engineering Design Course (QEDC) [11, 12]

Later in 2006, the “Quantum Engineering Design Course (QEDC)” was established [11] and selected by the Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT) as one of “The International Priority Graduate Programs (PGP) –Advanced Graduate Courses for International Students-” [12]. The “Quantum Engineering Design Course (QEDC)” is a special graduate school program (Master’s and Doctor’s) that aims to equip the new generation of young scientists -

- with cutting edge research skills necessary to anticipate and adapt to the ever-changing needs of the society, and
- a broad perspective of Science, Technology, and Society.

These should enable them to:

- elucidate emergent material functions, based on fundamental, microscopic-level understanding of natural phenomena involved (QUANTUM);
- realize a new generation of functional materials and devices (ENGINEERING); and
- propose novel alternative materials and technologies, for applications such as fuel cells and solar cells, among others, that are energy efficient and environmentally-friendly (DESIGN).

Researchers and research topics tackled, either theoretically and/or experimentally, span across the areas of Science, Engineering, Engineering Science, and Information Science & Technology. And, depending on the purpose, a prospective student can enter QEDC through either of the two generally schemes, viz.,

- degree seeking or
  - QEDC for Master & Doctor degrees (5 years)
  - QEDC for Master degree (2 years)
  - QEDC for Doctor degree (3 years)
- non-Degree seeking.
  - Short-term course (4–12 months)

3.1. Feature 1: Tailor Made and Team Teaching

The QEDC is an English program, where several students from different countries, e.g., Bangladesh, Canada, China, Germany, Indonesia, Iran, Malaysia, Philippines, Thailand, Turkey, South Africa, South Korea, Vietnam, have already been a part of this program. As the QEDC program is research intensive, each student is assigned to work directly under the academic supervision of a university professor. Furthermore, during the first year, each student is assigned a peer tutor, who provides individual assistance and guidance in their study and research, including assistance on instructions expressed in the Japanese language and advices on daily life. For details on the active involvement of QEDRI network members in the recruitment, evaluation, and acceptance of candidates, supervision and care of students, we refer the interested readers to [13].

3.2. Feature 2: Computational Materials Design (CMD®) Workshops and Linkage with other Programs

Another distinct feature of this program requires students to join in at least two of the several Computational Materials Design (CMD®) workshops held every year: twice domestically (ca. March and September), and once in each of the following countries: Philippines (ca. February-March), Thailand (ca. February), Malaysia (ca. May-June), Indonesia (ca. August-November), Vietnam (ca. December). The target participants of these workshops are researchers in the academe, industries, government agencies, and graduate students. It offers lectures as well as hands-on sessions. It also includes various items from the basic theory to the cutting-edge case studies provided by the working researcher. It helps the participants to enhance practical quantum engineering research capacities.

The purpose of these series of workshops is to provide the participants with a first-hand experience of how CMD® is carried out. It provides them with the basic knowledge and techniques to better prepare them for the new paradigm in materials science research. This program also gives sufficient consideration to arrange special curriculum and earn credits for exchange students. The requisite subjects are provided in English. Meanwhile, some optional subjects are provided in Japanese for the purpose of deepening the relationship between the foreign students and Japanese students. The student can acquire credits by attending the specified international conferences and seminars. For example, the students can get credits by attending lectures of the “Osaka University Advanced Nanoscience-/Nanotechnology-Related Inter-/Trans-/Multi-Disciplinary Graduate-Level Education, Research, and Training Program” [14], which is a significant nanoscience and nanotechnology program in Japan. For details on the importance of holding CMD® workshops in countries of QEDRI network members, we refer the interested readers to [13].


As an integral part of the program, the students are required to and provided with ample of opportunities to publish in the prestigious academic journals and present in international conferences.

3.4. Feature 4: Follow-up and Support [13]

As another integral part of the program, whenever possible, the QEDC alumni themselves become part of the QEDRI network, and act as QEDC ambassadors, recruiters, and mentors for the next batch of QEDC candidates/students.

4. What is Next?

So what is next? … QEDRI networks satellite offices/hubs … [2] Extension to double-degree programs … [11] We are still a long way from realizing a truly functioning network/consortium of universities (a Border Less, Knowledge-Networked Society). The same as someone planting trees under whose shade they may never sit. But then again, … when everyone begins to see the same dream, it begins to take shape and become reality …
References


3. cf., e.g., 量子デザイン・ユニバーサル戦略イニシアティブ (Universal Quantum Engineering Design Strategic Research Initiative/QEDRI)

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5. Former Dean: Masao TOYODA, Department of Manufacturing Science, Graduate School of Engineering, Osaka University, Suita, Osaka 565-0871, JAPAN, toyoda@mapse.eng.osaka-u.ac.jp.

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7. Incumbent Dean: Toshihiro TANAKA, Department of Materials Science & Processing, Graduate School of Engineering, Osaka University, Suita, Osaka 565-0871, JAPAN, tanaka@mat.eng.osaka-u.ac.jp.

8. Current QEDRI Representative and 1st Core Chairperson: Yoshitada MORIKAWA, Department of Precision Science & Technology, Graduate School of Engineering, Osaka University, Suita, Osaka 565-0871, JAPAN, morikawa@cp.prec.eng.osaka-u.ac.jp.

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10. 3rd Core Chairperson: Tamio OGUCHI, Institute of Science & Industrial Research, Osaka University, Ibaraki, Osaka 567-0047 JAPAN, oguchi@sanken.osaka-u.ac.jp.


12. 平成18年度「国費外国人留学生 (研究留学生) の優先配置を行う特別プログラム」
2006「The International Priority Graduate Programs (PGP)」Advanced Graduate Courses for International Students


Biography

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