iPodia – ”Classroom-without-Borders” Global Engineering Education

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1. Introduction

In light of the recent development of Massive Open Online Course (MOOC)\textsuperscript{1-3}, there are multiple key challenges that universities in the 21\textsuperscript{st} century must face: what is the new value proposition for on-campus learning, how to overcome the paradox posed by the tension between global presence and local virtue, and can we deliver quality global education right from our local campus? With respect to engineering education that always positions itself at the frontier of global education and distance education\textsuperscript{4}, not only these challenges are real and present, but also they are more pressing and complex. To address these challenges, this paper introduces a new "Classrooms-Without-Borders" global engineering education program called iPodia, where the first letter "i" stands for "inverted", "interactive", and "international” learning.

The iPodia program was initiated in 2009 by the Viterbi School of Engineering at University of Southern California. The goal is to leverage the emerging pedagogical and technological innovations to enable students around the world to engage in collaborative and interactive engineering learning across disciplinary, physical, institutional, and cultural boundaries. Using modern eLearning technologies enhanced by Telepresence capability over the Internet, students from different universities attend the same class in person at networked iPodia classrooms on their home campuses to learn with their classmates around the globe. iPodia students learn together from the same teacher(s) with similar course syllabus and content materials, and they must follow identical academic requirements. Such direct and active peer-to-peer learning affords iPodia students a unique opportunity to co-construct contextual knowledge of important socio-technical engineering subjects. As a result, iPodia enhances students' ability and skills to explore cultural diversity as an inspiration for global engineering innovation, while simultaneously enlarging their personal networks to become future global engineering leaders.

2. What is iPodia?

2.1 Pedagogical approach

The iPodia pedagogy is developed based on three basic hypotheses, as illustrated in Figure 1, that (1) contextual understanding is best achieved via direct engagements, hence the "inverted" learning; (2) what you learn depends on with whom you learn, hence the "interactive" learning; and (3) diversity increases learning opportunity for everyone, hence the "international" learning.

With respect to the first hypothesis, context is what learners use to make sense of subject content while learning and practicing. Unlike content, which can be taught by teachers with lectures, contextual understanding is often co-constructed when learners engage in discussions with each other. In the conventional learning process, the learners are first being lectured with subject content in school, and they are then asked to exercise problem solving at home to develop contextual knowledge by themselves. iPodia inverts the traditional schoolwork and homework
sequence by having students first watch online lectures at home to learn subject content before attending class to engage in guided collaborative activities with their classmates to develop contextual understanding. This is why the letter "i" in iPodia stands for inverted learning.

The second hypothesis is a corollary of the first one, and states that subject content can be learned "from" teachers (or textbooks) but contextual understanding is best developed "with" peers. As a result, student’s acquisition of contextual understanding depends on, to a large degree, the peers with whom they are learning. The inverted learning process explained above transforms the learning paradigm from passive (i.e., attending lectures) to active\textsuperscript{5-7} (i.e., participating in discussions) by turning the "learning-from" pattern into a "learning-with" pattern. iPodia takes the active learning approach one step further, emphasizing the interactive learning. Therefore, the letter "i" in iPodia also stands for interactive learning.

The third hypothesis is derived from the second one, because if what students learn depends on the people with whom they learn, then it is expectable that student’s learning opportunity is increased when they study with a diverse group of learners from different social/cultural backgrounds. Beyond the traditional emphasis of interdisciplinary learning, iPodia focuses on inter-cultural learning by means of connecting classrooms located on campuses in different countries and culture regions around the world. This international dimension significantly expands the learning opportunity for iPodia students, enabling them to interact with, and learn from, global classmates right on their home campuses. Students are more comfortable interacting openly and freely with their foreign peers in iPodia classes because they all feel (and in fact are) at home. This is why the letter "i" in iPodia also stands for international learning.

![Figure 1](image_url)

Figure 1: Pedagogical approaches advocated by the iPodia program

### 2.2 Technical platform

iPodia leverages modern learning technologies as means to realize its pedagogy. Today’s version of the iPodia technical platform aims to enhance the realism of classroom-to-classroom
connections across global distances. Unlike the distance education in which technology functions to enlarge the delivery distance of content knowledge from teachers to students (especially for the MOOC courses), iPodia features with the “no-distance” learning and hence relies on technologies to eliminate the physical distance between students located in different places around the world. Figure 2 illustrates an existing iPodia interactive classroom located at Korea Advanced Institute of Science and Technology, as an illustrative example.

Figure 2: An iPodia classroom located in Korea Advanced Institute of Science and Technology

In the interest of cost, an iPodia interactive classroom can be transformed from the existing distance education classrooms or video conferencing rooms, which are available at a great majority of leading engineering schools. In general, a distance education classroom can be renovated by adding necessary videoconferencing devices, whereas a video conferencing room can be transformed by adding more display devices and rearranging the room layout to meet learning (instead of conferencing) needs. A basic iPodia interactive classroom includes at least the following functional components: (1) videoconferencing system to connect to other iPodia classrooms, (2) display system to show remote classrooms and lecture content, (3) camera system to record and transmit images, and (4) audio system to input and output sound in classroom.

To facilitate peer-to-peer interactions beyond the weekly class time, the iPodia technical platform also integrates three key additions to the mutually connected classrooms located in different places of the globe:

(a) Learning Management System: In addition to gaining the synchronized “face-to-face time” with each other inside the classroom, students can review class archives and remain in constant communication with each in an un-synchronized manner via the Learning Management System (LMS). Figure 3 illustrates an iPodia course website built upon the LMS of the Blackboard System.
(b) Small Group Synergy: While working on team projects, iPodia students require dynamic forms of communication to facilitate remote collaboration that is more intimate and hands-on than a full classroom meeting. Utilizing web conferencing tools (e.g., such as Adobe Connect, WebEx, and Blue Jeans), student teams have the opportunity to interact via private chat rooms during class and self-organize project meetings after class to discuss research and share works as if they were meeting in person.

(c) Connectivity after Class: Upon the social networking platforms, iPodia students actively share media content that they find interesting and relevant to the course with each other. Such social interactions outside the classroom in turn facilitate new discussions inside the classroom, augmenting the inverted learning as students integrate personally relevant material into subsequent peer interactions. Figure 4 illustrates how the mobile messaging service (i.e., KakaoTalk) was employed to facilitate social interactions on mobile devices.

Figure 3: A typical iPodia course website built upon the Blackboard System
2.3 iPodia Alliance

An independent, nonprofit, global education consortium among leading universities, namely the iPodia Alliance, has been established since 2012. All participating iPodia universities retain their independent identities, degree programs, and curriculum requirements; and they work together strategically to develop new courseware and deliver joint classes via the iPodia platform to address important socio-technical engineering subjects and significant global challenges. As of spring 2014, current memberships of the iPodia Alliance are as follows (as illustrated in Figure 5).

- University of Southern California (USC), Los Angeles, USA;
- Peking University (PKU), Beijing, China;
- National Taiwan University (NTU), Taipei, Taiwan;
- Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea;
- Israel Institute of Technology (Technion), Haifa, Israel;
- RWTH Aachen University (AACHEN), Aachen, Germany;
- India Institute of Technology - Bombay (IITB), Mumbai, India;
- Escola Politécnica da Universidade de São Paulo (EPUSP), São Paulo, Brazil;
- Birla Institute of Technology and Science (BITS), Pilani, India;
- Qatar University (QU), Doha, State of Qatar.
There are three principles that govern the operations of the iPodia Alliance. First, the "equal-reciprocity" principle encourages members to strive for balance between iPodia courses offered to and received from the Alliance within a certain period. This ensures that the benefits of equal contribution can be shared among all participating members. Second, the "revenue-neutral" principle holds that members are responsible for the costs incurred by their participation in all activities, and no money (e.g., tuitions, etc.) will change hands between any Alliance members. This principle aims to promote a “not-for-profit” culture, which allows Alliance members to focus on collaborative win-win contributions. Finally, the "not-joint-degree" principle states that the Alliance's main goal is to share courseware development and collaborate on course delivery, rather than to create joint degrees among its member universities. This enables all Alliance members to maintain independence and uniqueness of their curriculum, which form the basis for their valuable contributions to the Alliance.

3. Case study

To date, a variety of iPodia courses have been developed, offered among different iPodia partner universities. The engineering subjects that were and are being covered include: “Principles and Practices of Global Innovation”, “Management of Global Engineering Teams”, “Computer System Architecture”, “Sustainability in the Built Environment”, “VLSI System Design”, etc. In general, the most suitable iPodia course shares three fundamental features:

(1) An interdisciplin ary and intercultural core (i.e., students’ learning experiences can be positively enhanced by the cultural diversity among participating learners);
(2) A focus on emerging subjects that are of global importance (i.e., this capitalizes iPodia’s unique setting of international learning right at student’s home campuses);

(3) A promotion of active learning on a global scale (i.e., this refers to the team-based project, where students from multiple campuses must collaborate with each other as learning cohorts).

This section presents a case study, which details how a typical iPodia course is structured with respect to its participants, course calendar, learning activity, challenge and practice, and course evaluation. The selected case is an existing iPodia course that has been offered for four consecutive years - “Principles and Practices of Global Innovations”. In the 2013 spring semester, this course was collaboratively developed and jointly offered by five member universities of the iPodia Alliance: USC, PKU, KAIST, Technion, and Aachen.

3.1 Course participants

Participants of this course include a total of 108 college students from the five participating universities. All universities carried out careful selections on their course participants. The purpose is to properly manage student’s expectations on this yet pilot course. In the interest of quality, the class size was internationally limited to 18 students in each participating university, except at USC where 36 students were recruited. Because of significant time differences on multiple locations, it was impossible to find a lecture time that was agreeable to all the five universities. As a result, depending on different lecture time, the class was divided into two parallel sessions: Session A (Morning Session at USC) and Session B (Evening Session at USC). The Session A consisted of 18 USC-Morning, 18 Technion, and 18 Aachen students, and the Session B included 18 USC-Evening, 18 PKU, and 18 KAIST students. Because the student recruitment was carried out by each university separately, course participants’ backgrounds varied among the five universities.

Furthermore, this iPodia course is also characterized by its global teaching team, which is composed of instructors (and their TAs) from the five universities. All contributing instructors are affiliated to the engineering schools, but they specialize in different engineering fields such as mechanical engineering, industrial engineering, and environmental engineering. In this course, they play different roles in designing, guiding different learning activities, as summarized in Table 2.
Table 1: Summary of participating student’s background

<table>
<thead>
<tr>
<th>Session</th>
<th>School</th>
<th>Registered</th>
<th>Grade Year</th>
<th>Engineering/Non-Engineering</th>
<th>Major</th>
<th>Male/Female</th>
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</thead>
<tbody>
<tr>
<td>Session A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>USC (A)</td>
<td>18</td>
<td>Sophomore and Junior</td>
<td>12/6</td>
<td>Engineering and business</td>
<td>10/8</td>
</tr>
<tr>
<td></td>
<td>Technion</td>
<td>18</td>
<td>Senior</td>
<td>18/0</td>
<td>Engineering</td>
<td>15/3</td>
</tr>
<tr>
<td></td>
<td>Aachen</td>
<td>18</td>
<td>Master</td>
<td>18/0</td>
<td>Engineering</td>
<td>15/3</td>
</tr>
<tr>
<td>Session B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>USC (B)</td>
<td>18</td>
<td>Sophomore and Junior</td>
<td>14/4</td>
<td>Engineering and business</td>
<td>9/9</td>
</tr>
<tr>
<td></td>
<td>PKU</td>
<td>18</td>
<td>Senior</td>
<td>6/12</td>
<td>All majors</td>
<td>10/8</td>
</tr>
<tr>
<td></td>
<td>KAIST</td>
<td>18</td>
<td>Juniors</td>
<td>18/0</td>
<td>Engineering</td>
<td>11/7</td>
</tr>
</tbody>
</table>

Table 2: Summary of instructional roles of different instructors

<table>
<thead>
<tr>
<th>Session</th>
<th>Faculty</th>
<th>Background</th>
<th>Specialized Area</th>
<th>Instructional Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session A (morning session)</td>
<td>USC Faculty</td>
<td>Chair professor</td>
<td>Mechanical Engineering</td>
<td>Lecture</td>
</tr>
<tr>
<td></td>
<td>Aachen Faculty</td>
<td>Chair professor</td>
<td>Mechanical Engineering</td>
<td>Team project</td>
</tr>
<tr>
<td></td>
<td>Technion Faculty</td>
<td>Chair professor</td>
<td>Industrial Engineering</td>
<td>Cross-cultural exercise</td>
</tr>
<tr>
<td>Session B (evening session)</td>
<td>USC Faculty</td>
<td>Chair professor</td>
<td>Mechanical Engineering</td>
<td>Lecture and team project</td>
</tr>
<tr>
<td></td>
<td>PKU faculty</td>
<td>Assistant professor</td>
<td>Environmental Engineering</td>
<td>Cross-cultural exercise</td>
</tr>
<tr>
<td></td>
<td>KAIST faculty</td>
<td>Associate professor</td>
<td>Industrial engineering</td>
<td>Oversea study</td>
</tr>
</tbody>
</table>

3.2 Course schedule

The course was structured into three learning phases. Phase I focused on "content lectures", when key principles of global innovations were explained systemically. Phase II was devoted to "context interactions", when important practices of global innovation were exercised collaboratively. Phase III provided a two-week oversea study opportunity to KAIST campus in South Korea to harvest students' learning results.

A. Phase I (January 24th to March 7th, 2013): classroom lectures to learn subject content

The class began on Thursday, January 24th, 2013 with an overall introduction lecture. During the first phase of seven weeks, the USC instructor explained the subject content (i.e., principles of global innovation) via live lectures from the USC iPedia interactive classroom. All these content lectures were broadcasted live from USC via webcast over the Internet to allow the remote participation of individual Technion, Aachen, PKU and KAIST students. Video and audio recordings of these content lectures were made available in the LMS for all students to view/review anytime. It was required that all students must attend/study these live/recorded lectures in synchronized (or un-synchronized) mode to finish the learning of all subject content by the end of Phase I. All students in both Sessions learnt the same subject content from the USC instructor.

B. Phase II (March 14th to May 16th, 2013): interactive activities to develop contextual understanding

After being prepared with the content knowledge, students were guided to engage in a variety of interactive learning activities during the Phase II of 10 weeks to develop (e.g., co-construct)
contextual understandings (i.e., the practices of global innovation) together with their global classmates. These interactive activities were designed to deepen students' understandings of the subject contents which they had learned in Phase I, and to enable them understand different global contexts of innovation to be demonstrated in Phase III. The activities included live discussions of key innovation concepts guided by the USC Instructor, cross-cultural exercises guided by the Technion or PKU instructor, and team projects guided by the Aachen or USC instructor.

Unlike the Phase I during which all students from both Session A and Session B had learnt the same subject content and followed the same class schedule, students in different sessions were assigned different problems to solve and followed different schedules during the Phase II. Furthermore, depending on different instructors’ diverse assignment requirements, the amount of weekly lectures designated to each interactive learning activity (i.e., context discussion, cross-cultural exercise, and team project) also differs between the two Sessions.

- **Session A**: USC-Morning + Technion + Aachen (a total of 54 students)
  - Weekly lectures were scheduled at 9:00am-11:00am, Thursdays, USA (PST with daylight saving, UCT/GMT-7), which is 7:00pm-9:00pm on Thursdays (IST with daylight saving, UCT/GMT+2) in Israel, and 6:00pm-8:00pm on Thursdays (GST with daylight saving, UCT/GMT+1) in Germany.
  - Session A students completed the following learning activities in Phase II:
    - 2 weeks of context discussion led by the USC instructor.
    - 2 weeks of cross-cultural exercise led by the Technion instructor
    - 5 weeks of “global innovation process” team project by the Aachen instructor.

- **Session B**: USC-Evening + PKU + KAIST (a total of 54 students)
  - Weekly lectures were scheduled at 7:00pm-9:00pm, Thursdays, USA (PST with daylight saving, UCT/GMT-7), which is 10:00am-12:00pm in China (CST without daylight saving, UCT/GMT+8) and 11:00am-1:00pm in South Korea (KST without daylight saving, UCT/GMT+9) on Fridays.
  - Session B students accomplished the following learning activities in Phase II:
    - 4 weeks of context discussion led by the USC instructor.
    - 2 weeks of cross-cultural exercise led by the PKU instructor.
    - 3 weeks of “innovative product design” team project by the USC instructor.

C. Phase III (May 19th to May 30th, 2013): oversea study to harvest the learning outcomes

The interactive activities in Phase II enabled all students to acquire important contextual understandings (i.e., global innovation practice and process) of the subject content as well as to develop mutual understandings of each other. These learning outcomes were solidified, compared, integrated, and leveraged during Phase III, when all students visited South Korea for two weeks in late May. The purpose of this short class gathering was to create a face-to-face collaboration opportunity for all student teams to continue, complete, and demonstrate their innovation projects together. Multiple local cross-cultural learning activities, such as project
presentation, guest seminars, company visits, and community services, were arranged by the hosting university KAIST. The course was formally ended on May 31st, 2013 in South Korea.

3.3 Learning activities

The learning activities of this iPodia course included: (a) content lecture (led by the USC instructor), (b) context discussion (led by the USC instructor), (c) cross-cultural exercise (led by the PKU or Technion instructor), (d) team project (lead by the Aachen or USC instructor).

(a) Content lecture

The first 7 weeks (the Phase I) were completely devoted to content lectures, when the USC instructor systematically explained the basic principles that underline and/or affect technological innovations on open, competitive, global markets. These lectures covered six content modules: S-curve\textsuperscript{10}, Time of Market Entry, Segment Zero Principle, Outsourcing and Offshoring, Red Ocean and Blue Ocean Strategy\textsuperscript{11}, and Kano Customer Satisfaction Model\textsuperscript{12}. The approach of flipped classroom was adopted according to the following procedure:

1) The instructor modularized the weekly lecture materials (e.g., PPT slides, video clips, etc.) as 5 key concepts whose contents were explained by 4-6 slides.

2) The lecture materials were posted on the LMS (i.e., Blackboard System) 48 hours before the scheduled weekly lecture time for all students to preview.

3) All students were required to complete the following three tasks upon the LMS 24 hours before the weekly lecture time:
   - Complete a short quiz to indicate that they have already studied the lecture materials.
   - Provide feedback to the instructor by filling out a “Pain Index” survey (i.e., very easy, easy, average, hard, very hard) to indicate how easy/difficult was for them to understand the content of every concept.
   - Participate in the weekly “Before-class Discussion” on the Discussion Board.

4) The instructor aggregated, analyzed students’ feedbacks in order to better prepare for the weekly lectures, for example, by means of clarifying confusing slides or creating new slides.

5) The instructor explained the improved lecture materials during a two-hour lecture.

(b) Context discussion

Context discussion was a very important part of the interactive learning activities in the Phase II, when students were guided to interact with each other in order to co-construct contextual understandings and global perspectives over the content materials that they had learnt during the Phase I. The USC instructor was responsible for leading the context discussions for both Sessions according to the following procedure:
1) Based on the results and feedback which students provided after learning the content lectures in Phase I, the instructor prepared a set of in-class discussion materials, questions, and problems, and posted them on the learning manager system.
   - The Pain Index survey served as the key linkage between content lectures and context discussions, because the instructor was better informed of students' learning needs.
   - The instructor devoted attentions to those content slides that most students feel "more painful" during content lectures. The instructor also reviewed students’ entries on the Discussion Board to prepare for what questions to ask and what problems to exercise for these painful slides/concepts.

2) The in-class discussion materials, which were posted on the learning management system 24 hours before the weekly lecture time, included further explanations of difficult contents, reflections of important concepts, problem solving examples, and interactive questions/answers.

3) The entire 2-hour class time was devoted to the in-class discussion materials, and all interactions were recorded for students’ after-class reviews.

4) After the class was over each week, all students were required to participate in the weekly "After-class Discussion" on the Discussion Board.

(c) Cross-cultural exercises

Important cultural differences among different customers, societies and markets, when properly understood and creatively leveraged, can become an inspirational source for global innovations. Based on this assumption, during the Phase II, two cross-cultural exercises were assigned to facilitate developing students' appreciation of other’s cultures, and to enhance their intercultural competences. For these cross-culture exercises, students from each university worked together as "work groups" (i.e., USC, Technion, Aachen groups for Session A, and USC, PKU, and KAIST groups for Session B). The two sessions were assigned different tasks designed by different instructors. The Session A was assigned to “describe a typical person in your own culture” and “describe a successful product/service that fails in a different culture”; whereas the Session B was assigned to “document the daily life of a typical college student on your home campus” and “present two currently popular news in your country”. Two weekly lectures in each session were designated for all groups to present their assignment results and to interact with other groups.

(d) Team projects

Project-based learning provided iPodia students a unique opportunity to validate, exercise, realize, and demonstrate what they have learned from context lectures, context discussions and cross-cultural exercises. Furthermore, they also provided intensive cross-cultural virtual teaming experiences, which are otherwise difficulty, if not impossible, to acquire in the traditional engineering courses. The importance of project-based learning in developing student’s “design
thinking” has long been recognized. The 54 students in each session were assembled into 9 six-member project teams across cultural, institutional and disciplinary boundaries. To promote cultural diversity and to balance campus contribution, no more than 2 students from the same university were included in one project team.

The team projects for different sessions were guided by different instructors (i.e., the Aachen instructor for Session A, and the USC instructor for Session B). Specifically, the 9 teams in Session A were assigned to “conduction research for toaster in their home market and identify latent customer requirements”. In contrast, the 9 teams in Session B were assigned to “leverage cultural differences to inspire novel innovation targets and come up practical means to improve the greenness and sustainability of university campuses across the globe”.

3.4 Practical challenges and best practices

In practice, we recognized two primary challenges of developing and operating an iPodia course, which is characterized by globally distributed instructors, students, and project teams. The first challenge is how to address the time (and academic calendar) differences among different global universities in order to make the course at least logistically possible. It turns out that the time difference, rather than the technology, is the real limitation that hinders the number of universities to be included in one global course. Because most of global universities have explicit (and strict) rules that no class can be scheduled in the midnights or early mornings of local time, it is practically difficult, if not impossible, to fit an U.S. institution, an Asian institution, and a European institution all into the same lecture time slot. As explained in Section 3.1, our solution was to divide the class into two Sessions (from the viewpoint of the US institution), Asian Session (or Evening Session) and European Session (or Morning Session). Although such a compromising solution made it possible to include multiple universities from more than two contingents within one course, many students had suggested that they expected more cross-session interaction opportunities. Another factor that must be considered is the different time practice among different countries. Daylight Saving is a good example. Although the Daylight Saving is a common time practice in the Western Worlds, it is less widely used in the rest of the world’s countries. Furthermore, the Daylight Saving begins/ends on different dates in different countries. Our solution was to make the lecture time at USC adaptable to any changes caused by the Daylight Saving. Take the Evening Session for example, before the Daylight Saving began in US, the local lecture time at USC was scheduled to be 6:00-8:00pm, and the lecture time was adjusted to 7:00-9:00pm after the Daylight Saving. By doing so, the local lecture time at PKU and KAIST became fixed to be 10:00-12:00 in Beijing and 11:00-1:00pm in Korea, respectively. The disadvantage of this solution is that it increased the difficult of fitting this course into the already tight class schedule of the USC students. For example, 6 out of 36 USC students reported time conflicts with other courses, and special approvals were requested for them to attend the course.

Second, various global universities have completely different academic calendars. In general, universities in the same continent are likely to share identical calendars, while it is not always the
Figure 6 illustrates the calendar differences among different iPodia partner universities in different continents. In general, there are two options to overcome the limitation of calendar differences. The first option is to prolong the current USC spring semester to cover certain summer months (or to extend the USC summer semester to cover certain spring months). The disadvantages of this option include: most of undergraduate scholarships cannot cover tuitions for summer courses, and it introduces new conflicts between the course with student’s summer internship. The second option is to offer more intensive lectures within a short overlapping period, for example 2-3 lectures per week. The downside of this option is that it leaves insufficient time for students to effectively practice what they learnt inside the classroom through interactive learning activities outside the classroom. Take the team project assignment for instance, it should be noted that the time difference also hinders these globally distributed student teams to effectively collaborate. Our final solution was to offer the course as a regular spring course at USC, but to divide the learning process into different phases (see relevant discussions in Section 3.2). During the Phase I, the web conferencing service (i.e., WebEx by Cisco) was used to enable individual Technion, Aachen, PKU, and KAIST students to virtually attend the live lectures at home using their personal computers. This is indifferent from the traditional distance learning practice. The effectiveness of using WebEx to support online learning has been validated by the Distance Education Network (DEN) at USC. Nevertheless, the disadvantage is that it was very difficult to motivate remote students, who were still enjoying their local winter recesses, to actively participate in lectures and to finish assignments in time. For example, the attendance rate of remote students on WebEx only averaged 37.5% during the Phase I. Table 3 shows the final course calendar as a result of the above considerations of time differences and academic calendar differences among the five participating universities.

![Figure 6: Academic calendars of different universities in different continents](image-url)
<table>
<thead>
<tr>
<th>Week</th>
<th>Aachen</th>
<th>Technion</th>
<th>USC-Morning</th>
<th>Learning Activity</th>
<th>USC-Evening</th>
<th>PKU</th>
<th>KAIST</th>
<th>Week</th>
<th>Phase</th>
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</thead>
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<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>1</td>
<td>1/25</td>
<td>3-5a</td>
<td>1/25 4-6a</td>
<td>iPodia Class Introduction</td>
<td>1/24 6-8p</td>
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<td>1</td>
<td>I</td>
</tr>
<tr>
<td>2</td>
<td>1/30</td>
<td>3-5a</td>
<td>1/30 4-6a</td>
<td>Content Lecture on Learning Module 1</td>
<td>1/29 6-8p</td>
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<td>3</td>
<td>1/31</td>
<td>6-8p</td>
<td>1/31 7-9p</td>
<td>Content Lecture on Learning Module 2</td>
<td>1/31 9-11a</td>
<td></td>
<td></td>
<td>2</td>
<td>I</td>
</tr>
<tr>
<td>4</td>
<td>2/1</td>
<td>3-5p</td>
<td>2/1 4-6p</td>
<td>Content Lecture on Learning Module 3</td>
<td>1/31 6-8p</td>
<td></td>
<td></td>
<td>2</td>
<td>I</td>
</tr>
<tr>
<td>5</td>
<td>2/22</td>
<td>3-5a</td>
<td>2/22 4-6a</td>
<td>Content Lecture on Learning Module 4</td>
<td>2/21 6-8p</td>
<td></td>
<td></td>
<td>5</td>
<td>I</td>
</tr>
<tr>
<td>6</td>
<td>3/1</td>
<td>3-5a</td>
<td>3/1 4-6a</td>
<td>Content Lecture on Learning Module 5</td>
<td>2/28 6-8p</td>
<td></td>
<td></td>
<td>6</td>
<td>I</td>
</tr>
<tr>
<td>7</td>
<td>3/8</td>
<td>3-5a</td>
<td>3/8 4-6a</td>
<td>Content Lecture on Learning Module 6</td>
<td>3/7 6-8p</td>
<td></td>
<td></td>
<td>7</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3/8 10-12p</td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3/8 10-12p</td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3/8 10-12p</td>
<td></td>
<td></td>
<td></td>
<td>I</td>
</tr>
</tbody>
</table>

Table 3: Final course calendar for the 2013 spring semester

Colors for location/time:
Germany (GMT+1:00) | Israel (GMT+2:00) | U.S. (GMT-8:00) | China (GMT+8:00) | Korea (GMT+9:00)

Yellow highlighted date/time indicates remote students can EITHER attend live lectures online OR watch recorded lectures at their own free time.

Thick border indicates local holidays on different campuses. Students can participate in scheduled activities online if they choose.

* After the joint iPodia class ends on 5/31, faculty may choose to continue some separate instructions according to their own academic calendar requirements.
Another challenge for this kind of virtual class is how to reinforce the sense of “cohesiveness” among participants outside the class. The two hour lectures on a weekly basis is far from enough to make students acquainted with each other and to collaboratively work together on team projects. During the initial years of running this course, our solution was to organize a short oversea study for the whole class either at the beginning or near the end of the class. Although students’ feedback clearly acknowledged the values of such an in-person meeting chance to their overall learning experience, the high cost greatly hinders the scale up of this model. Therefore, we also tried a variety of interactive learning tools to promote the peer-to-peer virtual interactions. The tools that were used for the 2013 spring class included: discussion board in Learning Management System (i.e., Blackboard System), web conferencing service (i.e., Adobe Connect), mobile messaging service (i.e., KakaoTalk), and social networking service (i.e., Facebook). The applications of these tools to support education, distance education in particular, can be found in many past literatures. To date, however, relatively few efforts have been devoted to integrate these tools together within one global course, and to investigate their unique roles in supporting different kinds of learner-learner interactions.

We conducted a qualitative data analysis over the text chat history collected from different interactive learning tools (i.e., discussion board, Adobe Connect, KakaoTalk, and Facebook). The purpose was to identify different types of learner-learner interactions (i.e., academic interaction, social interaction, and collaborative interaction) that occurred upon different tools. This study aims to answer two questions: (1) which tool is most effective in supporting what kind of learner-learner interactions; (2) are there any redundant (or complement) roles between different tools? Details of how this study was conducted and discussions of its result will be elaborated in another paper by the same author. Here we provide partial results in specific to the percentage of different types of interactions occurred on each learning tool, as illustrated in Figure 7. The results show that overall different tools play complementary roles in supporting different kinds of learner-learner interactions, but some overlapping roles in between certain tools may be leveraged to develop future learning tools. Based on the lessons learnt, a variety of new tools (e.g., Piazza, BlueJeans, and Instagram) are being deployed in our 2014 Spring course.
Besides, we share some lessons learnt from teaching this global engineering class during the past 5 years. Despite the “empirical nature” of these lessons, they might be found useful by other engineering instructors, who intend to develop similar global courses addressing different engineering subjects.

1. The collaborative teaching among instructors from different universities is no easier, if not more difficult, than the collaborative learning among students. This is especially true when the contributing instructors all come from different disciplinary backgrounds and have diverse teaching styles. Therefore, it is important to clearly define each instructor’s instructional role upfront. Take our course for instance, every instructor was only responsible for one certain assignment, with no cross-teaching on the same assignment.

2. Different universities use different grading scales (e.g., letter grade or numeric grade) and methods (e.g., grading on curve). Hence, it is important to reach an unchangeable consensus upfront whether the whole class is graded on the same method or if local class is graded separately (and differently). Also, students from different universities tend to underline different aspects of grading. Based on our empirical observations, for example, students from Asian universities tend to overweight the clarity of grading criteria, whereas American students tend to emphasize the transparency of grading results.

3. Compared to the local lectures, time management of the global virtual lectures becomes more challenging, because it will be affected by many more process variables. For
example, although today’s videoconferencing technology has been reasonably reliable, there remains unexpected disconnections caused by, for example, unstable Internet bandwidth. According to our counts, on average, the disconnection happened at the frequency of 1.3 times per one hour lecture, and every disconnection cost roughly 2 minutes, if not longer, for the instructor to resume the lecture where it was interrupted.

(4) The application of the project-based learning is more difficult for a global virtual class, because now the project must be carried out by the multicultural virtual teams instead of the monoculture local teams. Compared to the latter, the former often faces more social issues of establishing mutual trusts and cohesions\(^3\). In that regard, we took several measures to enhance the team effectiveness. For example, a few icebreaker activities were designed, the team formation was carried out in a semi-structured manner considering both individual preferences and necessity of balancing disciplines, the TA played more active roles in facilitating team communications, 20% of lecture time was allocated to virtual team discussions every week, etc.

### 3.5 Course evaluation

The course evaluations were carried out by each participating university separately, according to their standard evaluation procedures and formats. Here we only present the accumulated course evaluation result of the USC class. The USC course evaluation included two parts. The first part included 6 multiple-choice questions, which aim to investigate student’s overall satisfaction of the course. All USC students were asked to state their level of agreement of six statements on the 1-5 scale. The accumulated results are summarized in Table 4. The second part of the course evaluation included 12 open-ended questions, which aim to elicit student’s personalized course experience. A qualitative data analysis is carried out to investigate students’ answers, seeking for the deeper reasons of positive or negative feedback. The results are summarized in Table 5.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>I was able to immerse myself in other cultures during the time spent in the program.</th>
<th>I have gained a better understanding of another culture through this program.</th>
<th>The educational experience I had in this class was better than a class taught only in U.S.</th>
<th>This program met my expectations</th>
<th>My participation in the iPodia class was a valuable learning experience.</th>
<th>I would recommend this program to other friends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Value</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Max Value</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Mean</td>
<td>3.81</td>
<td>4.62</td>
<td>4.19</td>
<td>4.14</td>
<td>4.19</td>
<td>4.69</td>
</tr>
<tr>
<td>Variance</td>
<td>0.46</td>
<td>0.25</td>
<td>1.06</td>
<td>1.33</td>
<td>0.36</td>
<td>0.53</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.68</td>
<td>0.50</td>
<td>1.03</td>
<td>1.15</td>
<td>0.60</td>
<td>0.77</td>
</tr>
<tr>
<td>Total Responses</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
</tbody>
</table>
Table 5: Investigation of USC student’s personalized experience of the course

<table>
<thead>
<tr>
<th>Questions</th>
<th>Total Response</th>
<th>Positive Response</th>
<th>Most Frequently Mentioned Reason/Result</th>
<th>Negative Response</th>
<th>Most Frequently Mentioned Reason/Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did this course fit into your academic plan?</td>
<td>18</td>
<td>17</td>
<td>• Counted as a technical elective</td>
<td>1</td>
<td>• Scheduling adjustments</td>
</tr>
<tr>
<td>What was your objective in participating in this class and was it realized?</td>
<td>17</td>
<td>15</td>
<td>• to meet interact foreign students</td>
<td>2</td>
<td>• Team project was not challenging</td>
</tr>
<tr>
<td>Has your participation of this course influenced your academic or career goals?</td>
<td>20</td>
<td>17</td>
<td>• More prepared to work abroad</td>
<td>3</td>
<td>Unspecified</td>
</tr>
<tr>
<td>What advantages or problems did the iPodia format present?</td>
<td>15</td>
<td>12</td>
<td>• Interactions with foreign students</td>
<td>14</td>
<td>• Technical problems</td>
</tr>
<tr>
<td>Was the student experience enriched by the inclusion of PKU, KAIST, Technion, and Aachen students via the iPodia format?</td>
<td>18</td>
<td>18</td>
<td>• PKU students are very creative, smart, and hard working</td>
<td>0</td>
<td>Unspecified</td>
</tr>
<tr>
<td>Was it valuable to you having students from majors other than your own in this class?</td>
<td>17</td>
<td>16</td>
<td>• Team Project was greatly enhanced by cross-disciplinary perspectives</td>
<td>1</td>
<td>Unspecified</td>
</tr>
<tr>
<td>What are the most important activities to include in future courses?</td>
<td>16</td>
<td>16</td>
<td>• Larger and long-term project</td>
<td>0</td>
<td>Unspecified</td>
</tr>
<tr>
<td>What are the activities we should consider removing from future course</td>
<td>16</td>
<td>0</td>
<td>Unspecified</td>
<td>16</td>
<td>• Discussion board</td>
</tr>
<tr>
<td>What did you enjoy most about the course?</td>
<td>17</td>
<td>17</td>
<td>• Meeting new people</td>
<td>0</td>
<td>Unspecified</td>
</tr>
<tr>
<td>What did you enjoy least about the course?</td>
<td>17</td>
<td>0</td>
<td>Unspecified</td>
<td>17</td>
<td>• Lecture content</td>
</tr>
</tbody>
</table>


4 Measures on innovation and global preparedness

We measured the students’ preparedness for global workforces and their propensity for innovative thinking using two instruments that have been used by Ragusa’s engineering and other STEM education research.\textsuperscript{34-35} The results of these measures were compared to a national sample of 2079 students who have participated in National Science foundation funded engineering research at 17 universities nation-wide. Results of these two metrics are illustrated in the figures below. Figure 8 represents the results of the global preparedness metric.

![Preparedness for Global Workforces](image)

**Figure 8: Evaluation result of global preparedness**

The results of global preparedness indicates that overall the students who participated in the iPodia course outperformed the national sample of undergraduate students and that this difference was statistically significance (via an independent sample t-test; $M= 4.91, SD=.97$; $t(78) = 6.99$; Cohen’s $d = .723$). These results indicate a significant positive effect of the program on students’ preparedness for global workforces.
With regard to student’s propensity for innovation, which was a primary goal of the program, results are promising as well. Figure 9 below illustrates such results.

![Creativity and Propensity for Innovation](image)

**Figure 9**: Evaluation result of creativity and propensity for innovation

As was the case with students preparedness for global workforces, the students who participated in Podia course outperformed the national sample of undergraduate students and this difference was again statistically significance (via an independent sample t-test; $M= 4.56$, $SD=1.07$; $t(78) = 9.42$; Cohen’s $d = .649$). These results indicate a significant positive effect of the program on students’ propensity for innovation.

5 **Conclusions**

This paper introduces a global engineering education program called iPodia. The iPodia program was created to address some major challenges ahead of today’s leading engineering schools and elite higher education institutions. First, iPodia employs the inverted learning approach to turn away from content-based lectures and towards nurturing context for more effective engineering education, thereby creating a new value proposition for campus education in the future. Next, iPodia enables interactive peer-to-peer learning across geographical, institutional, and cultural boundaries to promote borderless learning, thereby overcoming the strategic paradox of global presence versus local virtue for elite universities. Lastly, iPodia implements the no-distance
education model to demonstrate that, in the age of pervasive information technology and the increasingly flattened world, high-quality global education can be effectively delivered at home.

Future works of the iPodia program include: invite more global universities to join the iPodia Alliance, develop more iPodia courses to address different engineering subjects, increase the class size to benefit more students, etc. In specific to the particular iPodia course of “Principles and Practice of Global Innovations”, the current works in progress include: (1) develop a set of evaluative metrics to assess participating students’ learning outcomes; (2) conduct a contrast analysis of the same course offered in different years in terms of how the course was designed differently every year and what were the impacts on students’ learning outcomes; (3) generalize multiple basic principles of developing similar global engineering courses.

Bibliography