Design and Evaluation of a Cross-cultural and Trans-disciplinary Global Innovation Course

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1. Introduction:

This paper aims to present our best practices of delivering a global engineering course, which features a unique cross-cultural and trans-disciplinary global learning experience. Based on the belief that a truly valuable global course ought to focus on the "socio-technical" subjects with international perspective and global significance, where social interactions and cultural diversities can influence technical, engineering business, and policy decisions, the focus of this global course lies in the subject of "principles and practices of global innovation". The course was collaboratively developed and jointly offered by five world leading universities, which included University of Southern California (USC), Technion in Israel, Birla Institute of Technology and Science (BITS) in India, Peking University (PKU) in China, and Korea Advanced Institute of Science and Technology (KAIST) in South Korea. Course participants included 32 American, 16 Israelite, 32 Indian, 16 Chinese, and 16 Korean undergraduates.

At the first glance, one of the most notable features of this global course is the usage of technology to enable and to enhance learning. Advancement of information and communication technologies makes it possible to deliver global learning experience right at local campuses. For example, the videoconferencing technology is used to realize the synchronized lectures among multiple networked classrooms on different campuses and in different countries. A variety of eLearning tools and web conferencing solutions were provided to facilitate collaborative activities of the globally distributed, multicultural, trans-disciplinary, and virtual teams. Although technology serves as the means to make possible this global course, its true significance hinges more on its pedagogy than technology. The "inclusion" of global learning is achieved by the synthesis of inverted, interactive, and international learning in networked classrooms on distributed campuses, while learning technologies are used strategically to enable the new pedagogy to enrich the learning experiences and outcomes of all domestic and international students on local and remote campuses at multiple universities. Such a different, if not unique, pedagogy is developed based on three basic premises: (1) contextual understanding is best achieved via direct engagements (as opposed to linear lecturing), hence the "inverted" learning, (2) what students learn depends on with whom they learn (instead of from whom they learn), hence the "interactive" learning, and (3) diversity increases learning opportunity for everyone, hence the "international" learning [1]. Furthermore, project-based learning is also deployed in order to enable students from different countries and across diverse disciplines to engage in the interactive peer-to-peer learning within the same virtual learning environment in order to develop their collaborative design skills that are otherwise difficult, if not impossible, to acquire in traditional engineering classes. Specifically, the class was equally divided into 16 project teams, each was composed of 2 American, 1 Israelite, 2 Indian, 1 Chinese, and 1 Korean students. These globally distributed teams were tasked a semester-long project to design "*a collaborative learning space on university campus*". They went through four major milestones and at least 7 virtual team meetings to accomplish the projects. The final project deliverables included three progress reports and one final presentation.

At conclusion of the course, some course participants voluntarily finished an anonymous questionnaire with respect to their overall satisfaction of the synthesized pedagogy of inverted, interactive and international learning, the project-based learning experience, and the technology-enhanced learning experience. The rest of this paper is organized following. Section 2 entails how this global class was designed and implemented in terms of background of participants, specification of learning technologies, rationale of pedagogy, and structure of project-based learning. Section 3 presents the accumulated results of course participant's satisfactions and feedbacks. Section 4 draws conclusions and outlines future works.

2. Course Design and Implementation

2.1 Course Participants

Participants of this global course were recruited from five global universities (i.e., University of Southern California, Technion in Israel, Birla Institute of Technology and Science in India, Peking University in China, and Korea Advanced Institute of Science and Technology (in South Korea) from five countries (i.e., USA, Israel, India, China, and South Korea). These universities are all members of the iPodia alliance which is an independent, not-for-profit, global consortium of world leading universities to promote the "classrooms-without-borders" paradigm. To date, this iPodia alliance consists of a total of 12 global universities located in 10 countries and 4 continents. So far, this particular global course has been consecutively offered for 6 years since 2009. In the 2014 spring semester, the class consisted of a total of 112 undergraduates, who were all carefully selected through rigorous application and interview process at every local participating school. The local class size was controlled to be no more than 16 students at each school, except the American and Indian class where 32 students were recruited, as the American class was divided into two class sessions and there were two campuses from the same Indian school participating the course. Because of the wide time difference on multiple campuses, the class was divided into two parallel sessions: Session A and Session B. The Session A enrolled 16 American, 16 Israelis, and 32 Indian students, and the Session B enrolled 16 American, 16 Chinese, and 16 Korean students. The class was divided into 16 multicultural virtual project teams, each with 7 members (i.e., 2 American, 2 Indian, 1 Israelis, 1 Chinese, and 1 Korean students). In terms of participant's disciplinary backgrounds, they major in a variety of different engineering disciplines such as mechanical engineering, industrial engineering, civil engineering, electrical engineering, etc. In addition, some participants in the USC and PKU classes were further recruited from the business school and the liberal art school. Table 1 summarizes participating student's backgrounds in the global class.

Table 1: Summary of course participant’s background

Session	School	Registered	Grade Year	Engineering/ Non-Engineering	Major	Male/Female
Session A	USC (A)	16	Sophomore and Junior	12/4	Engineering and business	8/8
	Technion	16	Senior	18/0	Engineering	15/1
	BITS	32	Senior and Junior	32/0	Engineering	26/6
Session B	USC (B)	16	Sophomore and Junior	12/4	Engineering and business	8/8
	PKU	16	Senior	8/8	Engineering and business	8/8
	KAIST	16	Juniors	18/0	Engineering	14/2

2.2 Technology Enhanced Learning

Instead of gathering all students physically in one place to gain a short term global learning experience, a variety of leaning technologies made it possible to deliver this semester-long (i.e., 16 weeks) global course right on multiple local campuses. Specifically, the videoconference technology is used to link the globally distributed classrooms to enable the synchronized lectures on a weekly basis, as illustrated in Figure 2; the online forum service (i.e., Piazza System) is used to build a virtual platform where instructors and students can freely ask questions, answer question and post notes, as illustrated in Figure 3; the social networking service (i.e., Facebook) enables course participants to expand their global social network outside the classroom; the learning management system (i.e., Blackboard) serves to document course materials and lecture recordings for participants to review after class; and the web-conferencing service (BlueJeans) is employed to support the team-based collaborations that occurred both inside and outside the classroom, as illustrated in Figure 1.

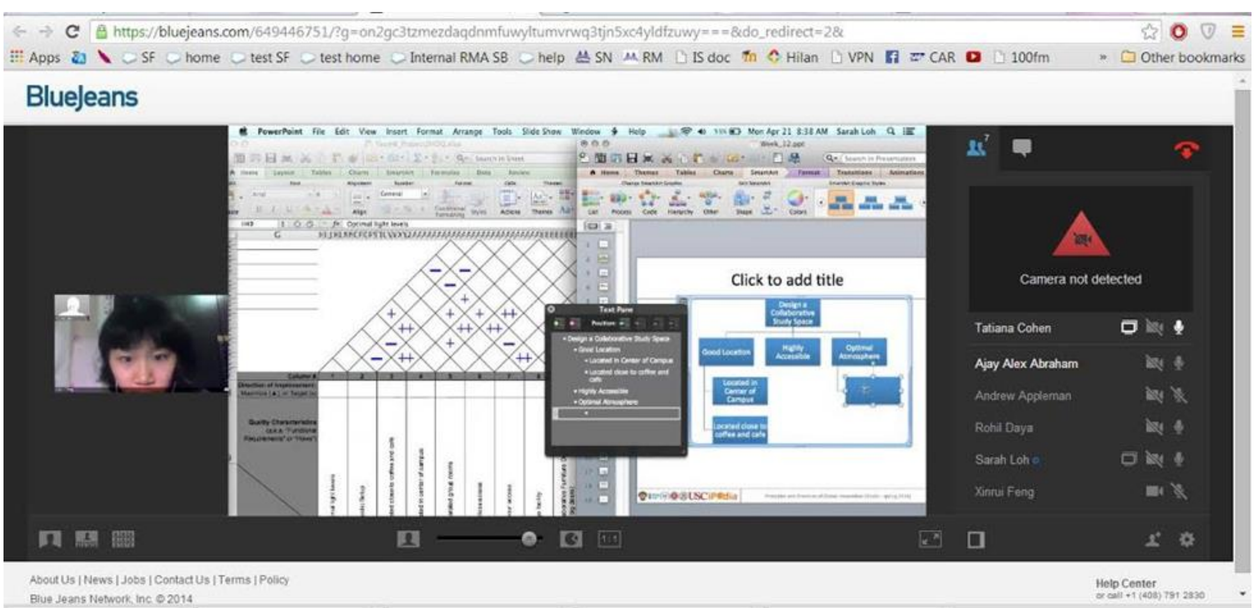

Figure 1: Team collaborations upon the web-conferencing platform (i.e., BlueJeans)

Figure 2: Connected classrooms made possible by the videoconferencing technology

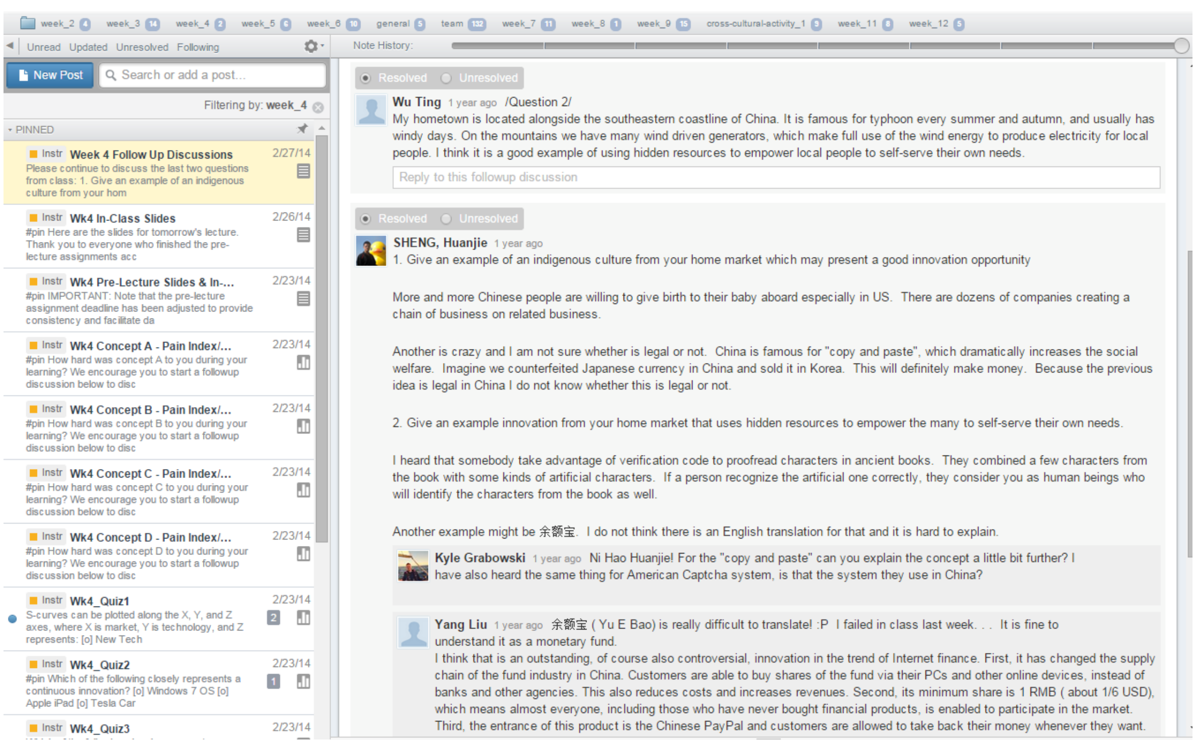

Figure 3: Q&A interactions occurred on the Piazza System

2.3 Pedagogy of Inverted, Interactive and International Learning

Above all, the inverted learning process goes beyond the popular flipped classroom approach [2-5]. In a typical flipped class, the instructor assigns preview materials to students based on what she/he thinks they need to learn. Students complete the homework before schoolwork begins; then the instructor goes through key materials during the class time with a mixture of lectures and/or exercises. The homework and schoolwork materials are same/similar in nature and are mostly based on what the instructor thinks students need to learn. With inverted learning, the instructor first assigns pre-class study materials, 72 hours before the class begins, based on what she/he thinks students need to learn. Then, globally distributed students on multiple campuses are required to complete these homework by assigning the “pain-index” as feedbacks for each studied concept, answering quiz questions, and participating in pre-class discussions to raise questions and help each other to resolve them. All these pre-class studies takes place online globally until 24 hours before the class when the instructor will collect and analyze all pain indices, quiz questions, and discussion threads to discover what students tell her/him what they would want to learn. Based on these pre-class feedbacks, the instructor then designs some interactive exercises to engage students to focus on what they want to learn in class. The ability to synthesize what students need to learn with that of what they want to learn is the key feature of the inverted learning. The complete inverted learning process includes a sequence of the following teaching/learning activities:

1) The weekly content materials of key innovation principles are organized into 4 to 5 key concepts, each is clearly explained by 5-6 PowerPoint slides with animations when appropriate.
2) This collection of 20-30 slides will be posted on the Piazza System at least 72 hours (3 days) before the in-class meeting time for all students to preview and study at home.
3) Together with the above weekly posting, a specific discussion area for each key concept will be created on the Piazza System for students to exchange Q&As and help each other as they study these content materials before the class.
4) While studying these slides by themselves before the class, students are required to complete the following three tasks on the Piazza System at least 24 hours (1 day) before the class begins:
    a. Answer multiple short quiz questions on the Piazza System to indicate that they have actually studied and read the content materials presented in these slides.
    b. Give online feedback by filling out a "Pain Index" survey (i.e., very easy, easy, average, hard, very hard) to indicate how easy/difficulty was for them to understand a particular key concept during the pre-class study [6].
    c. Contribute to, and participate in, the pre-class discussion and exchange of Q&As on the Piazza System. All the pre-class discussion participations are tracked and recorded.
5) During the live class time, the instructor will focus on explaining the details of some of the more difficult concepts based on students’ online feedbacks. 10-20 minutes “pondering time” will be allocated during the class time for students to engage in Q&As with their project teammates via the Bluejeans System.
6) After the live class ends, students are encouraged to continue the discussions and exchanges of further Q&As via the Bluejeans System. All after-class discussion participations are

tracked and recorded, and will be compared with those pre-class discussions to reveal the interactive learning effects.
7) All live class sessions will be recorded and posted on the Blackboard System afterwards for all students to review.

Next, because all in-class activities are specifically designed and fully devoted to what students really want to learn, all students from multiple campuses are highly motivated to actively engage with each other in interactions during the live class time, making the interactive learning an effective way for global learners to co-construct contextual understanding of course subjects while acquiring mutual understanding of each other. The interactive learning occurs at different layers. Above all, students from one university can interact with their counterparts from another university through the big screens in connected classrooms with high bandwidth audio/video connections. Furthermore, to enhance individual participation and collaboration, students are divided into small learning cohorts cross campuses each week. Members of these multi-campus learning cohort are required to login their private web-conferencing rooms before the class begins, and use this virtual meeting system to interact with their group mates directly across campuses during live discussions and exercises. Last not least, the interactive learning carries on beyond the weekly lecturing time via project teamwork throughout the semester.

Lastly, having integrated what students need to learn with what they want to learn via inverted learning and provided multi-layer collaboration platforms for students to engage and interact continuously via interactive learning, international learning is an additional feature that strategically brings global diversity into local classrooms to enrich all students' learning experiences in this globalized world. It should be note that the above inverted and interactive features of the pedagogy are equally applicable (and can/should be applied) to on-campus education. However, if students on local campuses can learn from and work with directly peers from different universities across physical, institutional, political, and cultural distances, they will certainly learn much more. The diversity brought into international learning becomes a very valuable new resource of classroom learning, which was unavailable from any textbooks, lectures, and short foreign travels before.

2.4 Project-based Learning

Project based learning is commonly recognized to be a useful method to teach the subject of innovation and design thinking [7-8]. In this global class, the assigned project is to design "*a collaborative learning space on university campus*". Since a great majority of course participants were lack of much tangible design experiences in the past, focus of the course was placed on the functional and conceptual design stages instead of the embodiment and detail design stages. The specific design methods that were taught included the Kano Customer Satisfaction Model [9], Quality Function Deployment (QFD) [10], Innovative Design Thinking [11-12], and Axiomatic Design Theory [13].

The project assignment was structured into four major milestones of sequential tasks: (1) perform an icebreaker activity for team building purpose; (2) perform QFD to determine functional requirements; (3) follow Innovative Design Thinking to generate design concepts; and

(4) make a final presentation to summarize the project process/outcome in front of the whole class. For each milestone, every team was required to organize at least two virtual meetings (except for the icebreaker task) to accomplish the assigned tasks following relevant design/innovation principles taught in class. In total, every team had devoted 7 virtual meetings to accomplish the project assignment. At conclusion of each meeting, every team was required to submit a meeting minute document to document the following information: a list of team members presenting the meeting; time, date, and meeting duration; a list of project ideas that were discussed, etc. It was made explicit to the class that all team members were expected to equally contribute to the team project, and everyone's individual project grade would be determined based on his or her contribution accordingly, based on a confidential peer assessment.

Firstly, an icebreaker task, namely "*guess what it is for*", was assigned for team building purpose. Specifically, based on understandings of their own culture and that of others, every team member was asked to choose and present one product/service, which they believe that their teammates from other cultures would not be able to tell its purposes. Such product/service must be real things that students commonly see/use on their home university campus, and must present true challenges to people with different cultural backgrounds. Next, all teams were asked to employ the Quality Function Deployment (QFD) that they learnt in class to systemically build a House of Quality (HOQ). The required deliverables of this task is a project progress report that includes the following outcomes made during the functional design phase: a collection of customer voices in terms of customer needs, wants, expectations, preferences and aversions; the choice of functional requirements; a short description of how QFD was performed, and its resulted House of Quality; and the decision of the prioritized CR and FR, and why. Next, all teams were asked to follow the Innovative Design Thinking (IDT) approach to systemically ideate a set of different design concepts (DCs), and to rationally select the functional simplest concept as their final design outcome. The required deliverables of this task is a project progress report that includes the following outcomes made during the conceptual design phase: a hierarchical organization of functional requirements, a description of how the IDT ideation process was performed to create new DCs, a set of different DCs that were ideated which are all represented using the IDT two-hierarchy structure, and a brief description of how the best DC was selected. Finally, all teams were asked to make a final presentation in front of the whole class to explain what had been accomplished through the semester. Each team was allowed a total of 13 minutes to make their final presentation, which included 10 minutes for presentation and 3 minutes for interactions with the audience. Content-wise, each team was required to include at least (but not limited to) the following portions in their final presentation: the interpretation of "collaborative space" and your choice of focus campus, a brief summary of how QFD was performed to identify the innovation opportunity, a brief summary of how IDT was carried out to create the innovation concepts, an elaboration of the final design solution, lessons learnt from this global innovation project, and multiple lead-in questions to engage the audience.

An illustrative example of one project team's project process/outcome is provided to indicate what has been accomplished out of this project assignment. This particular team had interpreted an ideal collaborative space to be "*an adaptable system to the needs of the group at hand, allowing for the space to change to accommodate different types of groups*", and they had identified the campus of the Indian University as their primary target, to which the final design was tailored accordingly. Figure 4 illustrates the cultural products that were discussed for the icebreaker task. Figure 5 shows the House of Quality built by the team following QFD. The team had identified the 4th functional requirement of "*to modulate light, sound, and space*" as their main focus of conceptual design, and Figure 6 illustrates the final design concept represented as functional and physical hierarchies.

Figure 4: Summary of cultural products discussed during icebreaker activity

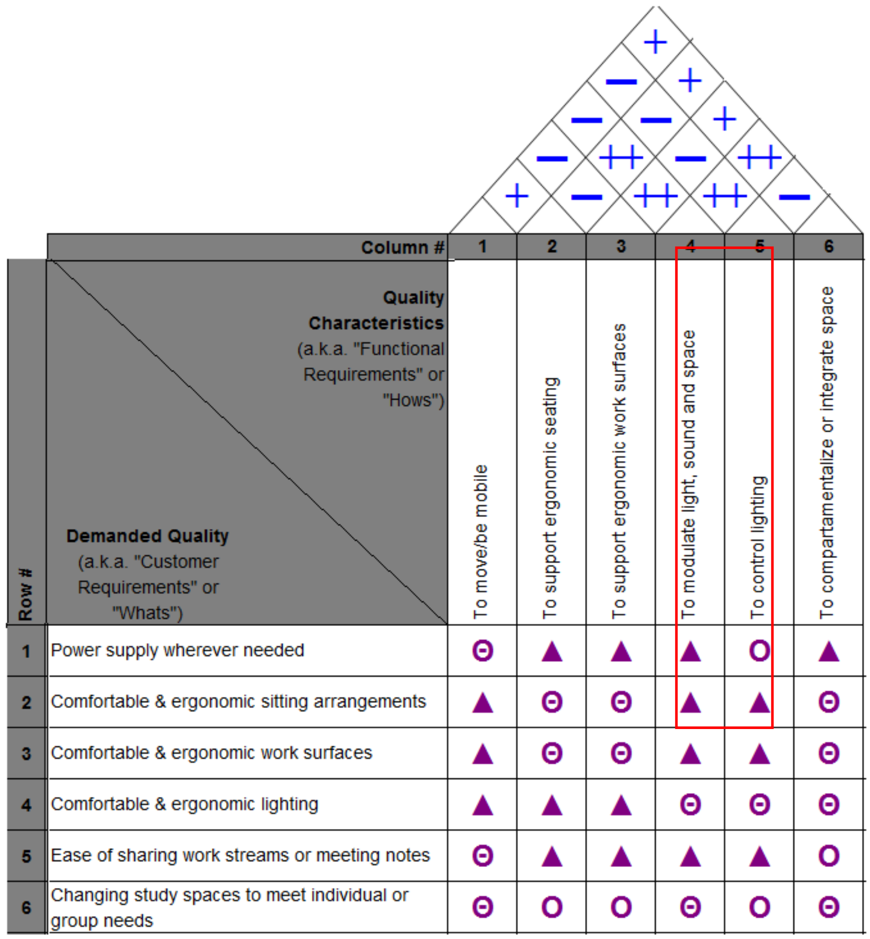

Figure 5: An illustrative example of House of Quality built by following QFD

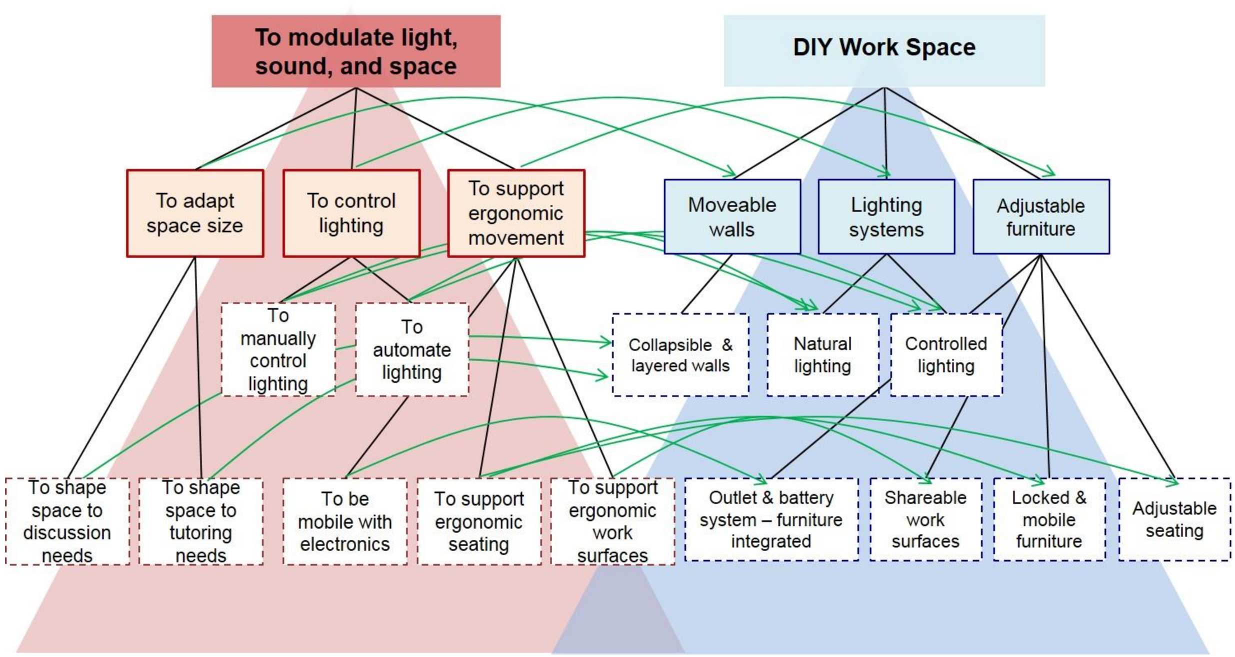

Figure 6: An illustrative example of the final design concept

3. Course Evaluation

At conclusion of the course, course participants were asked to voluntarily complete an anonymous questionnaire designed to solicit their reflections, satisfactions, and suggestions of their learning experience. A total of 56 responses were received. The accumulated results are presented with respect to (1) the pedagogy of inverted, interactive and international learning; (2) project-based learning; (3) technology-enhanced learning.

3.1 Evaluation of Inverted, Interactive and International Learning

This section presents participant's satisfaction with the inverted, interactive, and international learning experience, as illustrated through Figures. Overall, it is fair to state that majority of participants were satisfied with this new learning experience made possible by implementation of the new pedagogy. There are multiple findings that are especially worth highlighting. For the inverted learning, it is notable that half of the class had perceived "*an increase of workload*" because of the flipped learning sequence. For the interactive learning, although 91% of the surveyed population agreed that they "*gained a deeper understanding of another culture*", only 73% of them were satisfied with the "*peer-peer interactions occurred within the project teams*". For the international learning, despite the fact that 69% of the class agreed that "*participating the course improved their global social network*", 92% of them suggested that this was insufficient and they desire "*more peer-peer interaction opportunities to be created*".

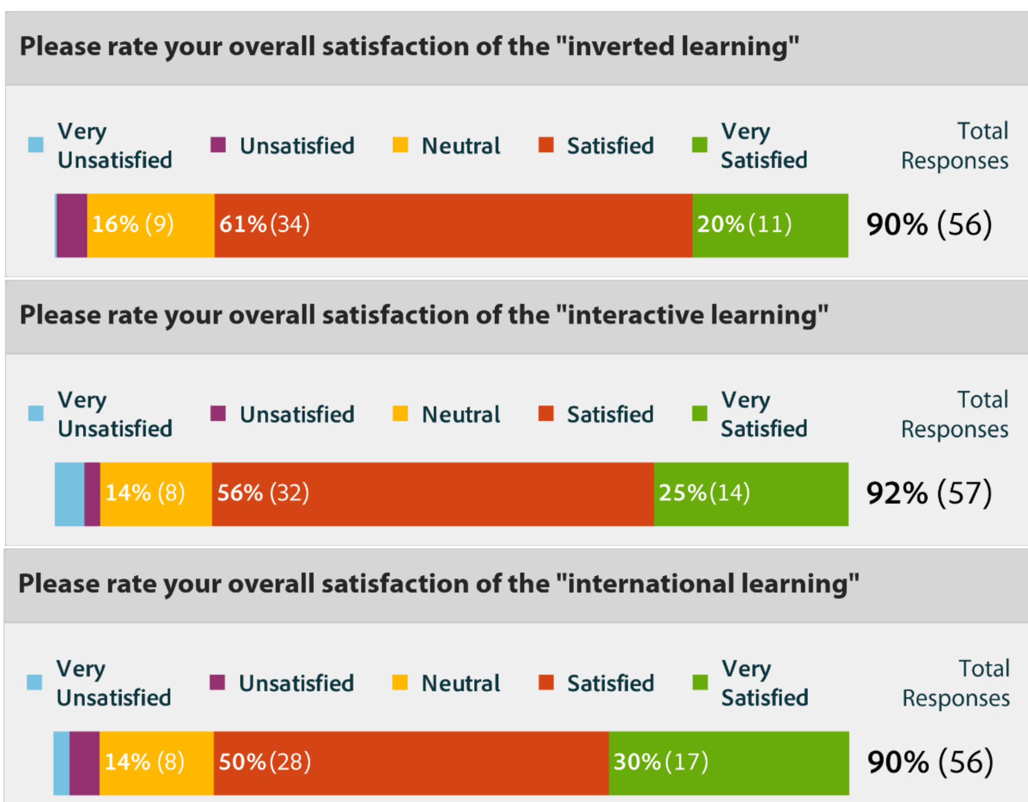

Figure 7: Participant's satisfaction with inverted, interactive, and international learning

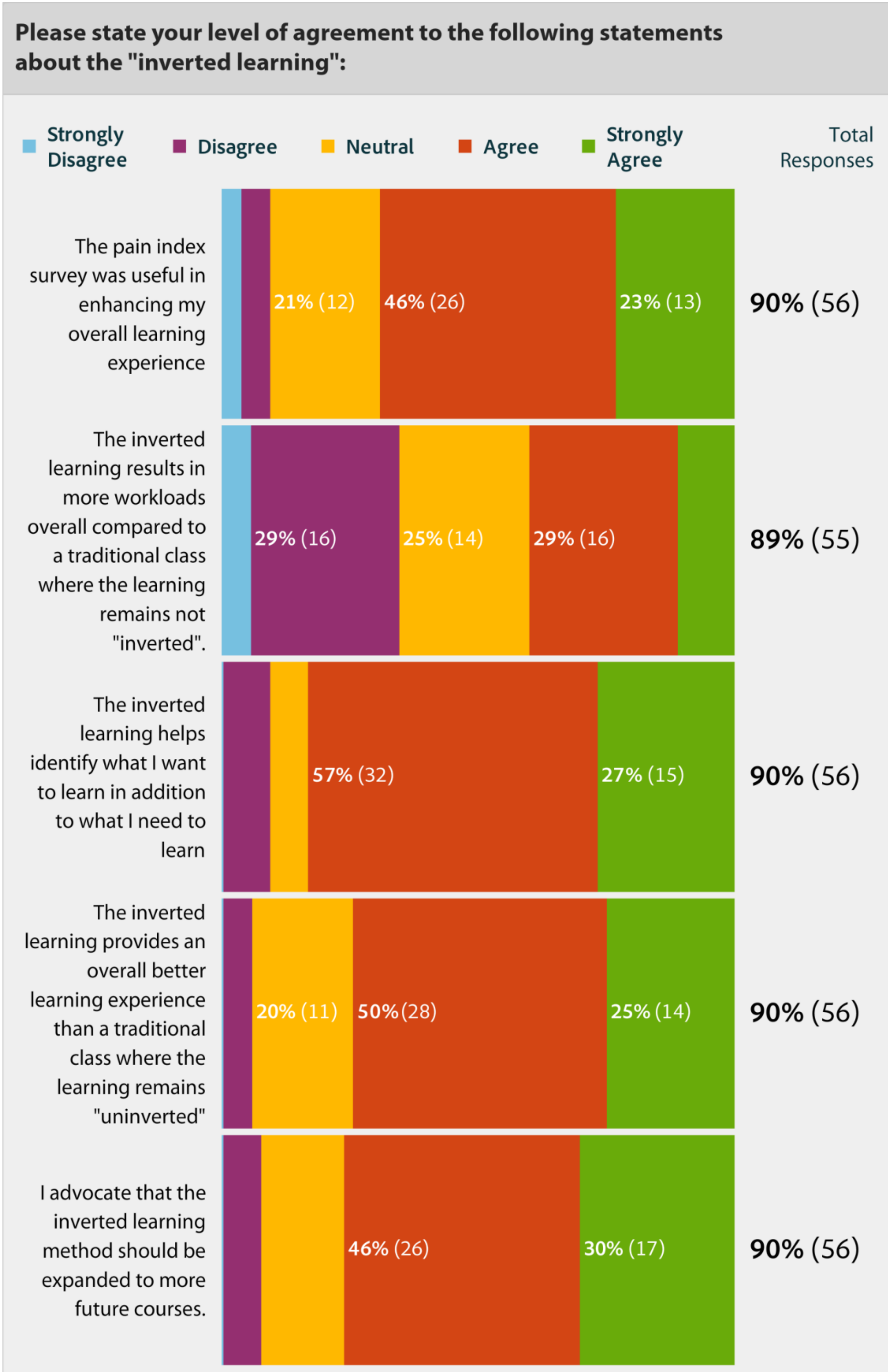

Figure 8: Participant's feedback on different aspects of "inverted learning"

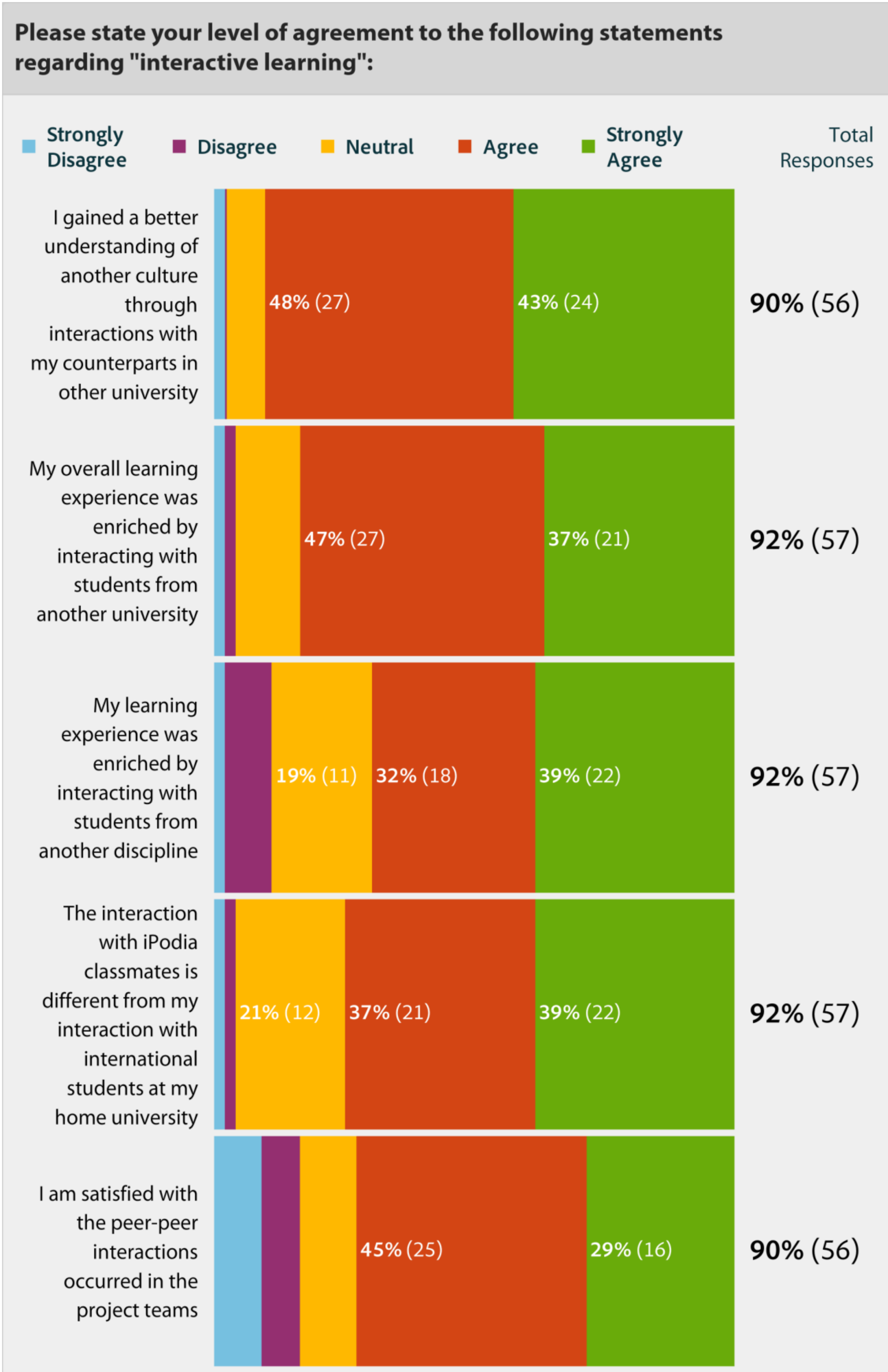

Figure 9: Participant's feedback on different aspects of "interactive learning"

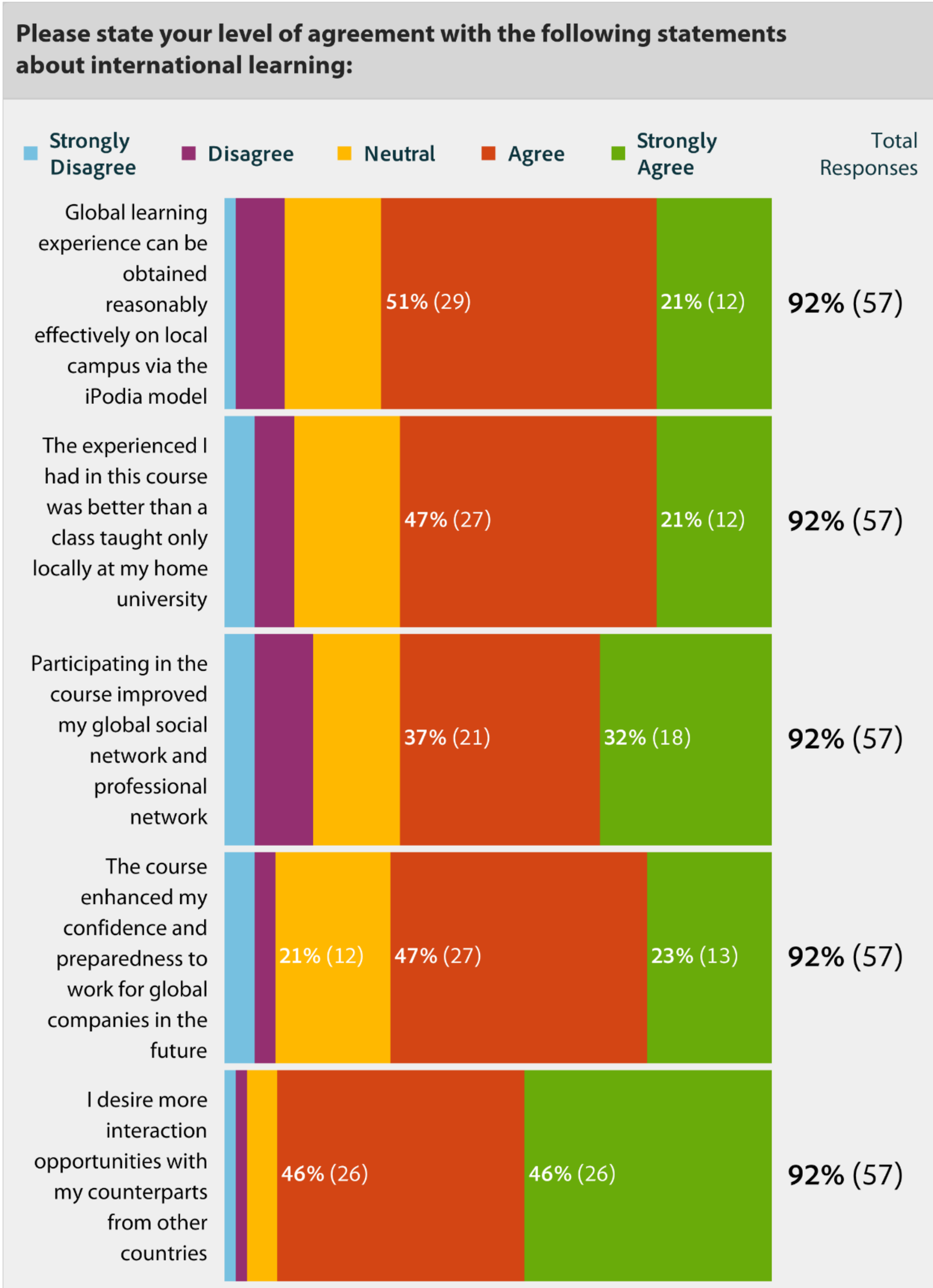

Figure 10: Participant's feedback on different aspects of "international learning"

3.2 Evaluation of Project-based Learning

This section presents participant's feedback of their project-based learning experience. The engineering and non-engineering students had perceived different level of difficulty of interpreting course content, as illustrated in Figure 11. According to a follow up interview of certain non-engineering participants, the course content "*was difficult for was not taught in a way that was as challenging as it could have/ should have been because inverted learning had allowed them to learn beforehand*". Majority of course participants suggested that, to a large degree (above 4 in the scale of 5), had their understandings of "design thinking" and "global innovation" been deepened through taking this course, as illustrated in Figure 12. A great majority of participates (i.e., 52% important and 25% very important) acknowledged the importance of the team project assignment on their overall learning experience in this global class, as illustrated in Figure 13. Many participants had criticized the choice of project topic, as the problem of "*collaborative space*" was "*very expansive and unclear*", "*not intellectual challenging enough*", and "*there were not many innovative ideas for it*". Some participants suggested that having "expert advisers" to present teams meetings would have been greatly helpful, as during the virtual meetings, if the team was confused of a certain method, they often went with their "*best guesses*" because of the tight timelines. Figure 14 illustrates participant's ratings on rigorousness of the individual project tasks. According to the follow-up interview, although many reflected that the final presentation was a good way of "*putting everyone together towards something tangible*", some suggested the task itself hardly contributed to the overall learning, as it was merely "*a time consuming task to summarize what we had learnt*", and it was "*very boring to watch largely the same presentations 16 times*". Management of the globally distributed teams is a highly challenging task and a very valuable research question [14-15], the various lessons learnt from this course about teamwork and task-work will be presented in a separate paper.

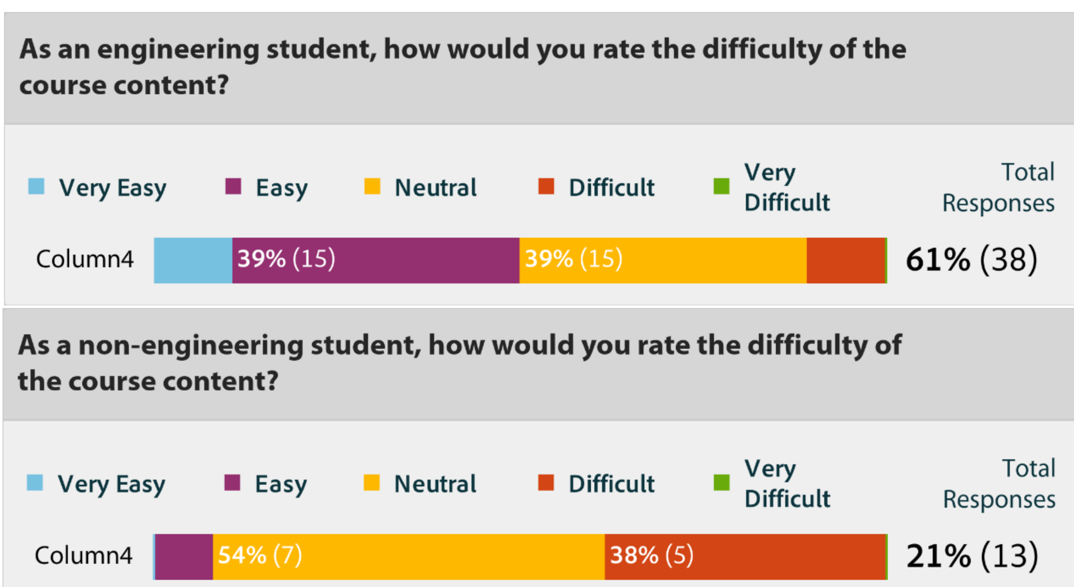

Figure 11: Participant's perception of the difficulty of team project

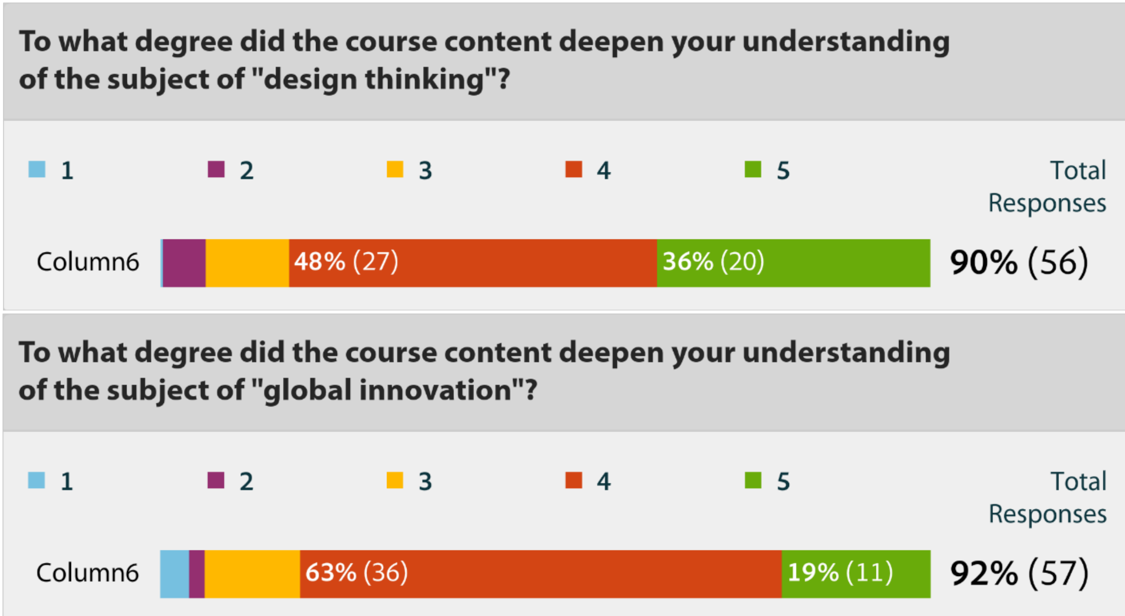

Figure 12: Impacts of project-based learning on participant's understanding of course content

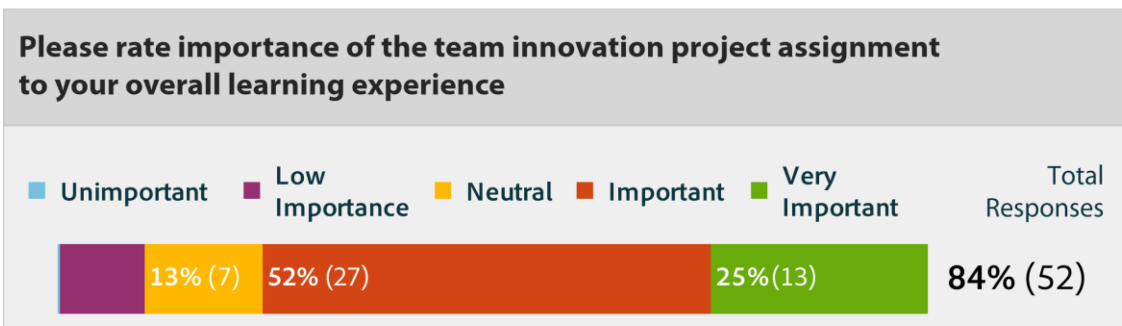

Figure 13: Participant's rating on importance of the project assignment

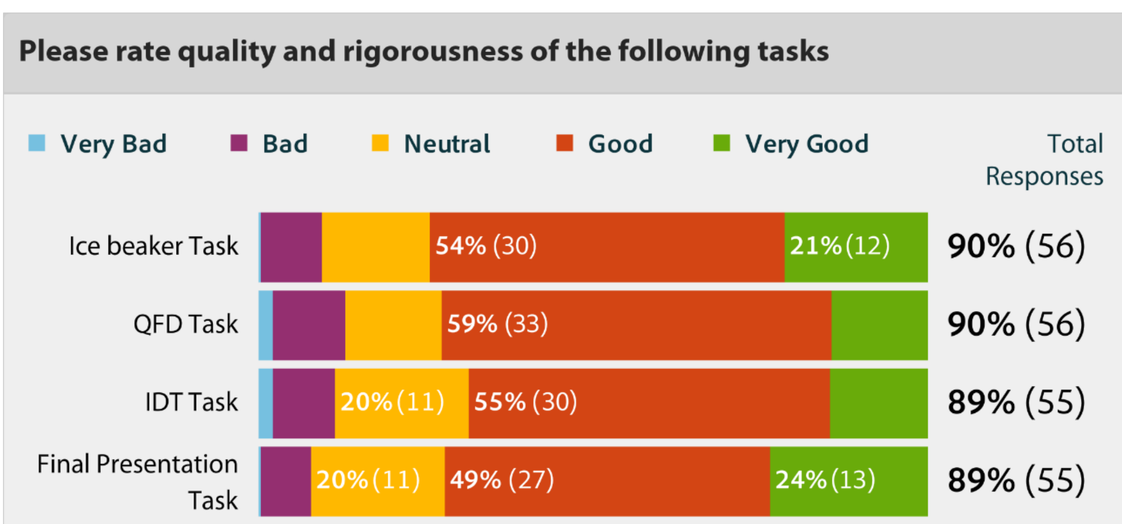

Figure 14: Participant's rating on rigorousness of individual project tasks

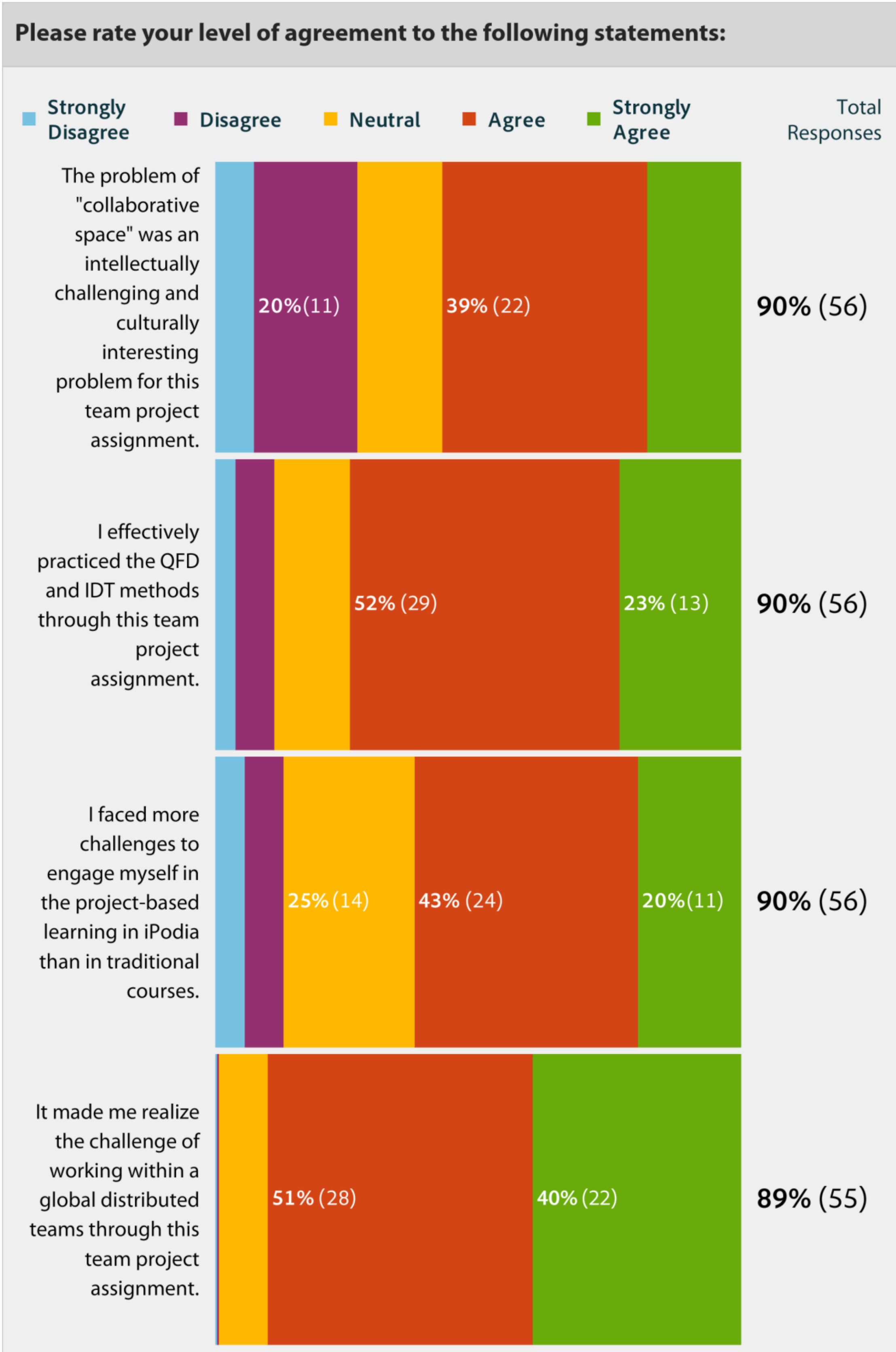

Figure 15: Additional questions regarding project-based learning

3.3 Evaluation of Technology Enhanced Learning

Figure 16 shows course participant's overall stratification of different learning technologies deployed upon this global class. Compared to student's overall satisfaction with the pedagogy and project-based learning, it is obvious that on average the class was less satisfied with their technology enhanced learning experience. In particular, over 50% of the surveyed population was unsatisfied with the web-conferencing system, which was intended to facilitate their project collaborations. In practice, multiple teams switched to other web-conferencing solutions such as Google Handout instead of the provided solution of BlueJeans. Furthermore, according to another separately conducted participant's peer assessment of their team effectiveness, multiple teams had identified technology limitation to be a major hindrance of effective teamwork as well as task-work.

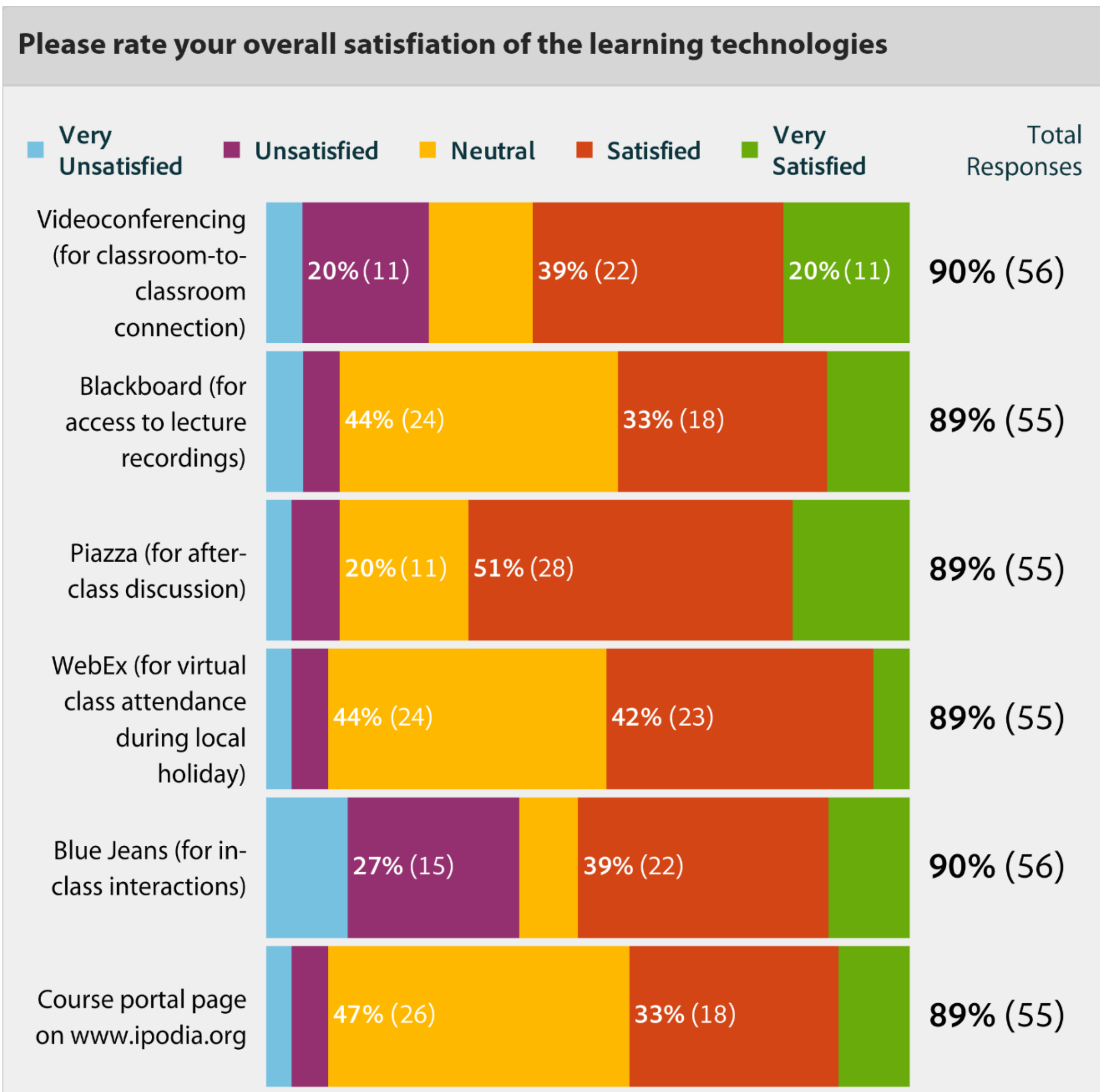

Figure 16: Participant's satisfaction on different learning technologies

4. Conclusion

This paper presents our best practices of designing and implementing a global innovation course in the 2014 spring semester, with the goal to provide students with a different, if not unique, cross-cultural and trans-disciplinary global learning experience. This global course features a new pedagogy of inverted, interactive, and international learning, together with the project-based learning and technology-enhanced learning experiences. According to the course evaluation results, on one hand, majority of students were satisfied with the largely localized global learning experience made possible by new pedagogies and emerging technologies. On the other hand, there remained many inevitable limitations that hinder the proposed model from reaching its full potentials in promoting high-quality global learning right on local campuses. The various lessons learnt from this study will provide guidance to improve our ongoing course redesign in the 2015 spring semester, towards a contrast analysis of participant's satisfaction between before and after new changes are imposed to the course.

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