Design of a Blended Learning ICT Education Program for Undergraduate Students in Asia-Pacific Based on Communities of Practice

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Abstract: This position paper reports on the design of the Asia Pacific Internet Engineering (APIE) Program: an ICT education program for undergraduate students in the Asia-Pacific region that utilize multiple resources and learning content from existing ICT-related Communities of Practice (CoP). APIE program consists of four components: self-paced online courses, synchronous online sessions, an onsite camp, and an internship. The program structure has been strategically designed to position APIE not only as an online courseware for knowledge acquirement but anticipating its potential to become a new CoP that fulfills the gaps between the current ICT education and the expectation from academia and industry. This study first introduces the program concept and describes the design of components and the implementation plans. It also presents preliminary results from the first pilot runs of the program.

1 INTRODUCTION

In May 2011, in a report by Frank La Rue, the United Nations Human Rights Council expressed the view that Internet access should be recognized as a human right (United Nations, 2011). The Internet is the cornerstone of our lives today. Therefore, the education and training of engineers who develop and support the Internet are essential for all countries and regions. In particular, innovations in information and communication technology (ICT) and other industries and services that utilize ICT are making an increasingly significant contribution to the economic growth of developed and developing countries (Aničić et al., 2016).

According to the OECD, people with the high-end skills needed to invent and apply ICT are in demand worldwide (OECD, 2016). On the other hand, IMF predicts that by 2030 there will be a global shortage of more than 85 million technical workers (IMF, 2019).

To overcome the current shortage of ICT professionals, higher education institutions in each country need to design ICT higher education program that leads to ICT careers for young people (Aničić et al., 2016). In contrast, researchers on ICT education and ICT careers reported that conventional engineering education has a gap between the skills learned in education and the skills required in the industry (Garousi et al., 2019; Freitas et al., 2018). There is also a lack of triggers for students to think about ICT careers (Calitz et al., 2011; Aničić et al., 2016).

Communities of Practice (CoP) is one of the concepts to solve such educational problems (Glaze-Crampes, 2020; Carrino and Gerace, 2016; Gilbuena et al., 2015). Wenger proposed the concept of CoP as *"groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly*" (Wenger, 1999). He states that the school is not a self-contained closed world for students to acquire knowledge to apply outside, but rather a part of a broader learning system. He argues that connecting the student's experience to actual practice through a wider community that crosses the school wall is essential when applying CoP to the educational field (Wenger, 1999). In other words, learning is not simply imparting knowledge but is a process of social interaction with "masters" who have more knowledge and know-how and peers in a specific context. Hence in communities, we can learn a lot.

However, it is not easy to design a CoP for ICT education in collaboration with multiple universities and industries beyond the boundaries of an educational institution or area, or nation. Also, attempts to design a

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CoP intentionally can miss the spontaneous nature of CoP (Pyrko et al., 2017).

CoP is often overlooked, but it's all around us (Wenger, 1999). Rather than designing a new CoP from scratch, we can expect to overcome these problems by designing an educational program that utilizes the existing multiple CoP and their resource. In addition, the educational program can be expected to be sustainable through collaboration among multiple universities and educational institutions. But as far as we know, there is no research on the design of educational programs or communities of practice that utilize existing multiple communities and their resources in a wide area that transcends national borders.

Our research team has been implementing the School on Internet Asia (SOI Asia) Project[1] since 2001 with the aim of establishing a wide-area Internet education platform in Asia. As of 2022, this project has 28 university and research institute partners in 13 countries in Asia-Pacific and continues to carry out practical activities. In 2022, we started a new initiative: Asia Pacific Internet Engineering (APIE) program[2], starting from this and related communities.

Developed by a multi-stakeholder partnership led by SOI Asia project that includes APNIC[3], AITAC[4] and WIDE project[5], APIE was inspired by the concepts of CoP (Fig.1). The program utilizes resources from existing Internet engineering communities in the multi-regions. The initial idea was to curate best practices of ICT education rather than creating new learning content from the ground up.

This paper describes the design and first implementation stages of the APIE program, an ICT education initiative for higher education students that aims to foster the next generation of IT professionals. APIE looks at the need to enhance roles and capacity for ICT-related careers in academia, industry, and Research and Educational Networks (RENs) in Asia Pacific. The program structure comprises four components: self-paced online courses (APIE Online), 10 synchronous online sessions (APIE e-Workshop), a one-week onsite camp (APIE Camp), and an internship (APIE Internship). Each component will be described in Chapter 3. They aim to bring together students from different backgrounds, ICT education-related scholars, and IT professionals to collaborate for learning and practice actively.

This paper will contribute to ICT education and CoP domains with knowledge about educational methods that utilize existing CoP in ICT education and ICT career education.

Figure 1: Multi-stakeholders involved in APIE design.

2 LITERATURE REVIEW

2.1 Communities of Practice

The concept of Communities of Practice (CoP) was first mentioned in Lave and Wenger's book about Situated learning (Lave and Wenger, 1991). They coined the term in their study of apprenticeship as a learning model. Apprenticeships are usually thought of as student-teacher relationships, but they are actually CoPs of a more complex set of social relationships (Wenger, 1999).

CoP can happen in online communities as well as onsite communities (Johnson, 2001). New technological developments have increased the benefits enjoyed by CoP members by facilitating long-distance communication. Voskoglou argues that web-based virtual CoP is a very promising tool, especially in developing countries (Voskoglou, 2019).

It has been reported that the use of CoP and community learning has a positive effect not only on ICT but also on STEM learning. STEM Learning Communities research aimed at recruiting, developing, and retaining students in STEM fields and increasing student achievement, graduation rates, and participation in STEM fields after graduation (Dagley et al., 2016; Inkelas, 2011). Carrino and Gerace reported that student participation in a STEM-based learning community improved aspects comprising academic self-regulation, STEM identity, metacognition, and self-efficacy (Carrino and Gerace, 2016). A paper examining four national CoPs developed to expand STEM pedagogy reform efforts in the U.S. found that philosophy and personal interactions (e.g., peer-to-peer

[1]https://www.soi.asia/
[2]https://apie.soi.asia/
[3]https://www.apnic.net/
[4]https://aitac.jp/english/
[5]https://www.wide.ad.jp/index_e.html

learning) were most important in the design of CoPs for engagement and outcomes (Kezar et al., 2017).

There are Professional Learning Communities (PLC) with a concept similar to CoP. Communities of practice are not necessarily aimed at learning (Wenger, 1999). In contrast, PLC are similar to communities of practice in that they are groups of professionals who share a common goal. but have a positive impact on students learning, and outcomes are differentiated mainly by their specific goal of providing (Glaze-Crampes, 2020; Stoll et al., 2006). In particular, most PLC studies are set in teachers and schools (Stoll et al., 2006), and they deal with more limited situations than the concept of CoP.

Glaze-Crampes argues that communities of practice are generally oriented towards sharing culture and knowledge within the community, but by shifting their focus to student learning, they become professional learning communities, which could be a vehicle for change in STEM education (Glaze-Crampes, 2020). She also stresses the need to share existing discipline cultures in new ways and to build interdisciplinary communities for the benefit and growth of students joining the discipline. Our research also attempts to design APIE as an actual learning program.

According to Leiner, the Internet is as much a collection of technologies as it is a collection of communities (Leiner et al., 2009). Furthermore, the Internet's success is mainly due to meeting the community's basic needs and leveraging it effectively to advance the infrastructure. This community spirit has a long history, beginning with the early days of Advanced Research Projects Agency NETwork (ARPANET). Even today, engineering communities like Internet Architecture Board (IAB) and Internet Engineering Task Force (IETF) contribute to developing and maintaining the Internet.

Taking advantage of the characteristics and the diversity of ICT communities as CoP, the APIE team aimed to design an educational program that curates and adapts resources from existing communities of practice rather than creating new and original ones.

2.2 ICT Education

The rapidly changing ICT landscape in recent years has meant that educators are under constant pressure to update their curriculum and course materials, and it has been suggested that because degree programs are updated so frequently. students (potential students) may enter ICT degrees without a clear understanding of what it means to study ICT, resulting in unsatisfactory educational experiences for some students (Sheard and Carbone, 2007).

According to Green et al.'s report, ICT professionals are no longer just technical experts and the ICT industry now needs workers with multidisciplinary skills (Green et al., 2013). Regarding the skills required by the ICT industry, many studies investigate the gap between the skills taught in university education and that skills (Gilbuena et al., 2015; Garousi et al., 2019; Freitas et al., 2018). A review paper investigating the gap between the skills learned in university education and those needed in the industry in the field of software engineering showed that hard skills (domain knowledge and technical skills) are not enough, and soft skills (team and interpersonal skills) have become even more critical in recent years (Garousi et al., 2019).

Studies by software developers working in companies highlight the need for undergraduates to gain real software development experience developing solutions to real problems in a team software development environment (Craig et al., 2018; Sherriff and Heckman, 2018).

2.3 ICT Careers

Not limited to ICT, as a general story about careers, unlike the stable employment and stable organizations of the 20th century, the digital revolution of the 21st century has led to a new social placement of work in which temporary staff and temporary projects replace permanent employees (Kalleberg et al., 2000).

These changes have also prompted university career centers to change their approach to students and have strengthened the movement to shift career centers from job placement agencies to conduits that promote connections (build human relationships) (Dey and Cruzvergara, 2014). Such career trends in recent years suggest that the importance of communities and human networks is increasing in career development. For example, Hughes et al. point to networking as one of the hallmarks of effective career education practices (Hughes et al., 2016).

The meta-analysis of ICT careers research by Aničić et al. anticipate that it will be possible to support further the preparation of graduates for the transition into society. Furthermore, these activities should be carried out in collaboration with all stakeholders, including faculty and non-faculty, industry, professional bodies, and other supporting agencies (Aničić et al., 2016). ICT undergraduates are generally unfamiliar with and lack information about current ICT careers and job descriptions, and lack awareness of ICT careers (Calitz et al., 2011). Calitz et al. state that universities must encourage students to explore new ICT careers opportunities and that ICT professionals

in industry should provide valuable information, such as giving guest lectures.

A study of ICT professionals in Malaysia found that high career adaptability is one of the critical aspects of survival, especially in the ICT industry (Omar and Noordin, 2013). Career adaptability here means "the attitudes, competencies, and behaviors that individuals use in fitting themselves to work that suits them" (Savickas, 2005), the ability to respond to change and plan for contingencies. The paper also argues that such career adaptability cannot be acquired overnight and that it is necessary to develop it consistently from the early stages of higher education institutions (Omar and Noordin, 2013).

3 PROGRAM DESIGN

The APIE program design is led by SOI Asia project core members from Keio University in Japan. The program has been developed in a multi-stakeholder partnership with institutions in the Asia Pacific and utilizes resources from existing Internet engineering communities in the region. AITAC is an IT human resource development organization based in Japan. WIDE project is a Japan-based international IT consortium responsible for the development and spread of the Internet. APNIC is the internet registry organization for the Asia Pacific that supports and provides capacity-building initiatives for IT professionals in the region.

Initial discussions about the course concept started in 2021. APIE was inspired by the concepts of communities of practice (CoP); it curates best practices and resources of ICT education and adapts them to a blended learning environment. The design team explored different learning environments to provide learners with a sense of community through a blended learning experience online and onsite.

The program structure comprises four components: self-paced online courses (APIE Online), 10 synchronous online sessions (APIE e-Workshop), a one-week onsite camp (APIE Camp), and an internship (APIE Internship). Each component described below was designed to stimulate collaboration between learners, ICT education-related scholars, and IT professionals.

The timeline for one cycle of this program starts with the self-paced online courses and the synchronous online sessions held fortnightly.

After completing those components, participants can apply for APIE Camp. It is a week-long onsite training program to deploy enterprise-level networks by themselves to make their knowledge more practical and valuable. APIE Internship will be provided in collaboration with stakeholders in related communities for those who completed all other components.

The first run of components, pilot versions of APIE Online and APIE Workshop, started in May 2022. Although the last session of the APIE e-Workshop was held in September 2022, APIE Online is still being produced and ongoing. Therefore, in this paper, we report on the design plan of the entire program and the progress of part of the pilot program that has been implemented until September 2022.

3.1 Self-Paced Online Courses

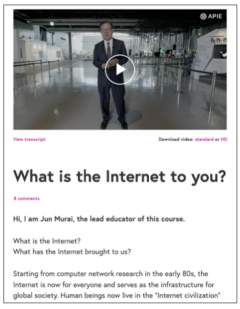
The self-paced online courses consisted of two 4- to 5-week courses at different levels described below (Fig.2).

The first course, named "Understanding the Internet," is an introductory course of 4 weeks, partially based on the online course "The Internet," [6] streamed in 2014 on Gacco [7]. Targeting a wider audience, the main aim was to broaden learners' thoughts towards the Internet and create opportunities for reflection on how they can contribute to the future of the Internet regardless of their academic background.

Learners are guided through the foundations of the Internet, its history, the design philosophy behind the technology, and global governance, among other topics, so they can acquire a clear vision of everyone's role in cyberspace and the importance of engineering for improving Internet infrastructure. The course includes theory, videos, readings, and introductory exercises so students can learn how to evaluate internet connectivity, investigate simple network problems and even debate security-related issues (Tab.1).

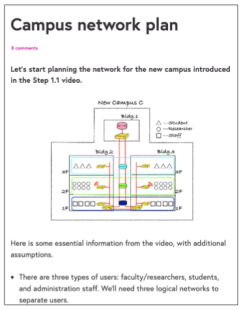
The second one, "Operating the internet," was structured as a 5-week course focusing on practical skills. The content comprises network technology-related topics from the physical layer (layer 2) to the application layers (layer 3), such as Ethernet, routing, DNS operation, and network design. Through theory and hands-on exercises, learners can experience situations like designing and deploying small networks and equipment configuration. By the end of this course, learners are expected to be able to identify and solve problems in network operation and debate network security risks (Tab.1). The course material was developed based on existing training courses for network engineers created by AITAC and APNIC. The hands-on practices run in virtual laboratories provided by the same organizations.

[6] www.wide.ad.jp/About/report/pdf2014/part06.pdf
[7] https://lms.gacco.org



Course1
Understanding the Internet
(4weeks)

1.What is the Internet?
2.How is the Internet?
3.Applications on the Internet?
4.Internet-based society



Course2
Operating the Internet
(5weeks)

1.Plan your network
2.Routing & routers
3.Switching & physical connectivity
4.Managing the name & address
5.IPv6 Fundamentals

Figure 2: Self-paced online courses' each weeks syllabus (Left: Course1, Right: Course2).

Table 1: Learning outcomes of self-paced online course.

Course 1: Understanding the Internet
• Explain what is the Internet • Explain how the Internet is running • Describe the technology behind the Internet • Discuss the importance of global collaboration to make the Internet • Discuss the individual responsibility for the future Internet • Discuss the future of the Internet • Evaluate your internet connectivity • Investigate the network problem in your house • Debate privacy and security issues related to the Internet • Explore your career in the Internet industry
Course 2: Operating the Internet
• Design and deploy a small network • Identify problems and fix them in daily network operations • Apply configuration on network devices for network deployment • Debate network security risk and protection on daily network operation • Apply basic configuration on services running on the Linux server for network operation

A significant design improvement added to the original courses is the introduction of a navigator who guides learners through different topics and content. For this role, an actual graduate student was chosen to shorten the distance and create more connections with young learners. In addition to explaining concepts related to the main topics, the navigator also interviews professionals and invites learners to the exercises.

The courses were structured following FutureLearn[8] platform guidelines (Fig.2). The content is divided into chapters called "weeks," and each week has sub-chapters denominated "steps." The steps can accommodate content in different formats (articles, photos, illustrations, animations, and videos, among others) depending on the needs of the learning objectives. A summary closes each week with a relevant article or an online discussion to stimulate communication among learners.

As previously mentioned, the course content was developed based on redesigning existing materials from other courses. Although online courses tend to keep learners attached to a single platform to avoid dispersion, this program stimulates learners to go to different platforms in several moments. By doing so, they can take advantage of the diversity of learning tools and environments online. The main learning journey starts on FutureLearn. For virtual labs exercises, learners are guided to go to the APNIC Academy platform[9] and come back to share and continue their learning. The course also has a dedicated Padlet[10] for sharing online discussions, in addition to the comment fields on FutureLearn. Links to materials and readings from different sources are also introduced throughout the courses to complement learning. After completing their tasks, learners return to FutureLearn to continue their learning path.

3.2 Synchronous Online Sessions

The second component of the APIE program blended learning model is a series of synchronous online sessions called e-Workshop (Fig.3). Conducted every two weeks, these sessions offer learners a variety of content that complements what students learned in the self-paced course. This component works as a community-building opportunity where learners can learn directly from IT professionals and expand their vision about different careers in ICT fields.

The e-Workshop series was designed to match the content provided by the self-paced courses. The first four sessions correspond to the first self-paced course (Understanding the Internet), and guests are professionals from different fields such as internet service

[8]https://www.futurelearn.com

[9]https://academy.apnic.net/

[10]https://padlet.com/

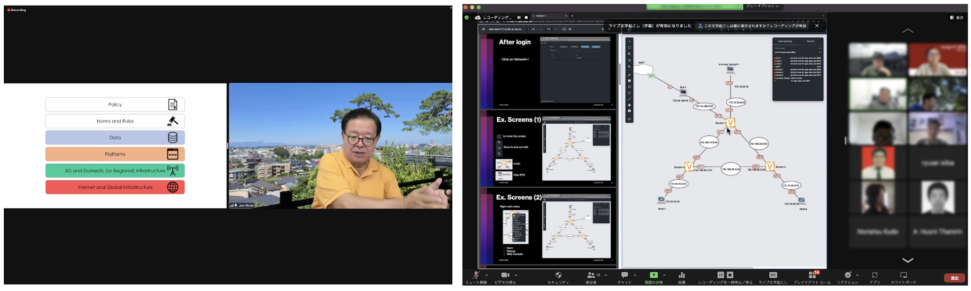


Figure 3: Scenes from the e-Workshop (Left: Guest keynote, Right: real-time lecture for the virtual lab).

providers, internet governance, telecoms, and members of RENs, among others. Guests shared their personal experiences and knowledge and challenged learners to reflect on what they expect and how they can contribute to the future of the Internet.

Sessions 5 to 10 were synchronized with the second course (Operating the Internet). Although it focused on hands-on activities with IT professionals, the syllabus included mobile networking, which was not in the original course curriculum.

3.3 Onsite Camp

The onsite camp component has been designed as a project-based intensive activity to allow learners to consolidate their learning outcomes from the online courses and strengthen the community-building aspect of the program. Learners who have completed both self-paced and synchronous session components are eligible to participate in the activity.

The full 5-day program's syllabus (Tab.2) was designed as a series of daily mission cards—from virtualization and DNS to cloud computing—aiming to help learners put their network design and implementation skills into practice. In addition to practical and theoretical skills leverage, the camp design aims to provide learners with opportunities to collaborate with others, meet and interact with professionals (lectures from AITAC and APNIC and mentors), and visit relevant local companies and organizations such as data centers and internet service providers.

3.4 Internship

One of the program's objectives is to build connections between academia, the network and Internet industry, and RENs in the region. Although faculties and professionals understand the need to improve and strengthen those paths, they agree that students should be more exposed to practical skills before graduating. According to initial discussions, learners who completed all other three components are eligible to be a candidate for the internship program. Internship programs are expected to play a crucial role in helping students broaden their views about their careers and reflect on the contributions they can make to build the future of the Internet. Internship component design is in the early stages of conceptualization.

Table 2: Content of APIE Camp.

Day	Content
Day1	• Kick-off and ice-breaking session • Network Deployment – Network design and configuration for new campus (L2 and L3)
Day2	• Virtualization – Work with rack-mount servers – Deploy hypervisor on the server – Install Linux on a virtual machine – Set up Web/DNS servers
Day3	• DNS – Authoritative DNS for campus subdomain – Full-service resolver
Day4	• Cloud computing
Day5	• Site visit (Datacenter, SOC, etc.) • Summary of the course

4 PRELIMINARY RESULTS

APIE program started calling for participants among SOI Asia partner universities in February 2022. The first run was conducted beginning in May to September. However, due to changes in the self-paced course component, Course 2 - Operating the Internet is still ongoing and scheduled to end by late March 2023. A group of 35 students from Japan, Indonesia, and Bangladesh attended the first run of online courses.

The preliminary results described below were collected from three different sources: an online survey

with students after the end of APIE Course 1, observations from the design team, and feedback from the advisory and curriculum committees during a review session held in November 2022, between the end of the APIE e-Workshop and the APIE Camp.

4.1 Feedback from Learners

An online survey was conducted with learners who finished Course 1, but only six responded. Despite the limited sampling, the results revealed interesting feedback from participants. Regarding the course content, respondents considered the volume and content of Course 1 favorable, in contrast with the second half of the course (Weeks 3 and 4) described as "long and challenging to complete." The program promptly set up office hours to support students' progress. According to the staff's observation, a considerable part of the learning was facilitated by a team of teaching assistants (TAs) formed by graduate students.

Some respondents mentioned that their English communication skills were at the beginner level, indicating that they likely faced challenges in absorbing the content provided. The APIE core team observed that learners prefer text-based communication for asking questions. Some used direct messages, making it challenging for other mentors to track all questions. This indicates that learners needed language support or even wished to study in their native language.

The team of TAs played an essential role in supporting both asynchronous and synchronous learning. TAs communicated with learners using different channels such as Slack and FutureLearn and helped them keep track of their learning activities. Since most learners were originally from Indonesia, an Indonesian TA was hired to reduce language barriers.

Respondents also expressed approval for the social learning aspect of the APIE program. One mentioned, "This (program) is the best online learning experience of my life because I have never studied with people outside my country." Others highlighted the talk by a guest speaker about his carrier, saying that "it gives me motivation."

4.2 APIE Review Session

In addition to the feedback from participants, an APIE Review Session was held in November 2022 in Manila, and attendees were members of the APIE advisory committee, APIE curriculum committee, APIE core team, and other related staff.

The course's overall concept, program structure, content curation and production, and the first implementation run got positive feedback from committee members. Attendees also extended special approval for Course 1 for its potential to invite all internet users to learn about the fundamentals of the Internet.

Several points for course improvement were also raised. The first was the need to define a more straightforward methodology to assess students' skill levels after completing the program to ensure the program meets the industry's requirements.

Another point emphasized was the necessity to strengthen connections and collaboration with the private sector. Attendees mentioned that this could fill the gap between the program content and the required skills for the IT industry. The third point raised was the importance of supporting students to access the workplace into network jobs through this program.

Finally, all learners who successfully finished both online courses are male students from two Indonesian universities. This shows that improvements can be done to the program's visibility to attract a wider range of students and increase cultural diversity and gender balance among learners.

5 CONCLUSION

The results from the first run of APIE Courses and APIE e-Workshop indicated that the program has the potential to achieve its initial goals. However, it also revealed room for improvements that have already started to take place. The online courses are being reviewed to shrink the gap between courses 1 and 2 and overcome language barriers. The program curriculum will adopt a problem-based approach that will give more substance to learning outcomes. A more detailed course evaluation is on planning and is expected to be conducted after the first implementation of the camp and internship components.

The onsite camp component is expected to allow learners to consolidate their learning outcomes and strengthen the community-building aspect of the program. The pilot version of the camp has been planned to start in February 2023, and 13 learners have already confirmed their participation.

Regarding the internship component, the APIE team is in conversations with potential sponsors (organizations, enterprises, etc.), which will welcome learners to the last phase of the APIE program. The internship is expected to start in mid-2023.

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