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What Should Be Considered when Developing ICT-Integrated Classroom Models for a Developing Country?

Hyunjin Cha [1], Taejung Park [2,*] and Jongwon Seo [3]

[1] College of Hyangseol Nanum, Soonchunhyang University, 22 Soonchunhyang-ro, Shinchang-myeon, Asan-si, Chungcheongnam-do 31538, Korea; lois6934@sch.ac.kr
[2] College of Liberal Arts and Interdisciplinary Studies, Kyonggi University, 154-42 Gwanggyosan-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do 16227, Korea
[3] International Initiative and Cooperation Section, KERIS, 64 KERIS building, Dongnae-ro, Dong-gu, Daegu 41061, Korea; jseo1972@gmail.com
* Correspondence: edutech@kgu.ac.kr; Tel.: +82-31-249-9509

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Abstract: This study aims to identify factors to be considered when developing Information and Communication Technology (ICT)-integrated classroom models and to suggest a conceptual framework for considering more appropriate classroom models, tailored to the environments and needs of each developing country. In-depth interviews were conducted with experts, yielding many factors to be taken into account when integrating ICT in various educational contexts of developing countries. The factors are categorized into five domains: current status and relevant policies in ICT education, ODA (Official Development Assistance) goals and priority setting, infrastructure and technical challenges, pedagogical methods, and educational resources. Based on the recommendations elicited for the five categories, we suggest a conceptual framework that provides practical guidance on the criteria for selecting classroom models suited to each partner country's environments and contexts. This study also draws implications from the interviews for classroom design guidelines related to hardware and infrastructure, to improve the sustainability of ICT-integrated classroom projects.

Keywords: ICT-integrated classroom; ODA (Official development assistance); developing countries; conceptual framework; ICT4ED (ICT for education development)

1. Introduction

As Information and Communication Technology (ICT) is becoming an integral part of our lives, it has been considered as a crucial key and means to solve social problems and promote economic development [1]. In the education sector, many researchers have also tried to make use of the great potential of ICT, which provides teachers and students with exciting and effective opportunities. Today's students, immersed in technology from a very early age, have spent their daily lives using computers, smartphones, and digital media [2,3]. They prefer utilizing media and technology in almost everything they have to do. Therefore, as a good method for them to be engaged in education, the integration of technology into learning environments and teaching contexts has been taken into consideration. [4].

The World Education Forum 2015 [5], the international community, and different organizations also highlight the importance of the United Nations 2030 Agenda for Sustainable Development, which underlines that interconnectedness and new capabilities for the 21st century through ICT can provide great opportunities to accelerate human development and economic progress. ICT is also considered as an important means to achieve Sustainable Development Goal 4 (SDG 4), by eliminating the digital

divide between nations, regions, and even social classes. The international community and society are making efforts to ensure equity and inclusion in education through ICT [6,7].

However, although many previous studies have discussed the design, implementation, and evaluation of ICT-integrated learning environments in general K-12 schools of developed countries, fewer research has focused on creating them in the schools of developing countries. There are constraints on creating ICT-integrated learning environments and spaces in the developing world, including limited infrastructure and educational resources and the lack of skilled teachers [8]. Therefore, researchers and stakeholders should not integrate technologies into the education of developing countries with the same contexts and models of the developed countries. They should consider the challenges of educational technology along with its opportunities within each developing country. In this respect, the *developing country* for this paper can be defined as a country which is receiving ODA from other countries or international organizations due to such challenges.

The power and capabilities facilitated by the integration of ICT in education might be wider and broader than supposed when regarding it simply as an instructional method. Indeed, ICT-integrated learning environments and spaces such as classrooms should be designed and developed so as to address the innovation and sustainability of schools in developing countries. Good educational design is needed to ensure that what the participants—including policy-makers, teachers, and students—need, seek, and have achieved is aligned with the nested set of learning spaces, facilities, resources, and even arrangements [9]. The integration of ICT into education needs to be more holistic and focus on the basic educational infrastructure, so as to support low-cost educational environments with higher quality access and to benefit more effectively from the infrastructure and investment, specifically in developing countries [10].

In preparation for the 4th Industrial Revolution, it is important not only to ensure equal access to learning for all students, but also that both rich and poor groups in developing countries have the opportunity to develop global competency and knowledge. In this respect, international organizations, including UNESCO [11] and UNCTAD [12], as well as previous studies, have emphasized the integration of ICT into education in an effective and efficient way. Against this backdrop, when policy-makers decide to invest in ICT and apply ICT to education initiatives, including ICT for educational development (ICT4ED) under ODA projects, there are many variables to be considered. Thus, the current study addresses the following two questions.

1. What factors should be considered when developing ICT-integrated classroom models that are appropriate for each country's situation in a developing country environment?

2. What is the conceptual framework for selecting ICT-integrated classroom models in the context of the environments of developing countries?

2. Theoretical Background

2.1. Designing ICT-Integrated Learning Environments

ICT-integrated learning is not restrictive with respect to any type of technology or pedagogical approach, but concerns all contexts and environments where technology plays a crucial role in making learning more engaging, effective, and efficient [9]. Currently, an initiative to discuss designing ICT education environments will be a step closer to enhancing future core competencies for learners, because the enhancement of future core competence occurs through participating in student-centered and active learning activities that emphasize the role of practical contexts and cooperative learning. The remarkable development of technology has brought learner-centered learning to a new phase of expanding learning spaces and diverse learning opportunities [13]. The Organization for Economic Cooperation and Development (OECD) [14] predicts changes in future schools in the core educational capacities required by future societies and the educational environment, curriculum, and teaching methods. Schools that pursue future education need to promote improvements in the school space. In other words, schools that prepare for future education must cope quickly with these changes and

improve their space and facilities [15]. Indeed, such school environments and space arrangements should be changed in a way suitable for training future human resources by newly reorganizing the educational purpose, curriculum, and education methods [16].

Studies by Macho [17], Ghavifekr and Rosdy [18], and a number of other researchers have confirmed that the use of ICT in education would help enhance students' learning. Previous researchers have shown that teaching with the use of ICT facilitates the learning process in a positive way and makes students more actively engaged in learning [19]. Furthermore, educators and instructional designers have been investigating what characteristics make technology an effective vehicle for education [20]. A shift toward ideas about good education and student-centered learning activities intersects with a trend toward a greater use of technology [9]. Moreover, technology is considered as one of the essential factors in transforming the developing countries for sustainable growth [18].

The general concept of ICT-integrated educational environments is helpful for learners and teachers to overcome the spatial limits of classrooms, by virtue of the unique potential of this technology [21]. There is a conflict between those who consider ICT-integrated learning simply as the educational use of technological systems [22] and those who interpret it specifically as the development of ICT tools and programs that represent constructivist theories and principles of learning and teaching [23]. In spite of this conflict, educators who wish to effectively utilize and integrate ICTs in instruction should use or apply pedagogical and instructional design principles as well as technological design principles to create a range of ICT programs and tools in relevant educational contexts [21]. Thus, there is a requisite for a mix of the technological and pedagogical perspectives for designing and developing ICT-integrated learning environments.

2.2. Integrating ICT into the Classroom in Developing Countries

There are two viewpoints on conducting projects of ICT for educational development (ICT4ED) in developing countries with official development assistance (ODA) resources [24]. Some educational practitioners insist that ODA in the education sectors should focus on the traditional teaching and learning environments, since there is often a great lack of classrooms and resources [25]. They also argue that the educational environments in developing countries do not afford opportunities to integrate ICT into education due to limited infrastructure, network and electricity problems, a lack of trained human resources, etc. [26]. On the other hand, international organizations, including UNESCO, have conducted a variety of ICT4ED projects to promote the transformation of education in developing countries [11].

In fact, Yim [27] noted that such a deep gap between the two viewpoints might originate from differences in the evaluation of the influence of ICT on educational objectives. Normally, educational practitioners with negative opinions about supporting ICT4ED think that the use of ICT in K-12 schools is an optional choice in teaching and learning as one of the instructional tools. However, previous studies have demonstrated that ICT might play a broader role in transforming educational systems in partner countries [28,29]. Kozma [29] insists that ICT has made significant impacts on the global economy by transforming economic systems and social paradigms in alignment with ICT.

In fact, ICT-integrated classroom construction and implementation initiatives not only involve technical matters but are more multifactorial [30]. Indeed, the purpose of such initiatives should be considered in the broader and wider context of the partner country from a holistic viewpoint [28,31].

In this respect, a wider range of research on the framework for ICT in education initiatives and ICT4ED programs has been conducted to find the components, processes, activities, methods, and assessments to be applied when integrating ICT into national educational contexts and environments. Rodríguez et al. [30] divided them into three categories based on a wide-ranging investigation of the literature on ICT in education, determining that there are many studies of frameworks for the integration of ICT in K-12 schools. The relevant research investigated various factors affecting the implementation and integration of ICT in educational environments. Table 1 summarizes the literature about factors to be considered when developing ICT-integrated classrooms.

Table 1. A summary of literature reviews about factors to be considered.

	Reference	Purpose	Results
National studies	Brown cited in [32]	To find out factors involved in ICT integration in education	five multifactorial aspects were found out
	Baskin and Williams [32]	To investigate the ICT integration levels, impacts and challenges in 18 Australian regional schools.	Use of an intensive instrument consisting of eight distinct domains and twenty-two question sets and variables
	Tondeur et al. [31]	To evaluate a model which determines the ICT integration in primary education from a multidimensional and multilevel perspective	an integral and multidimensional relationship between many different factors
	Veenstra (1999, cited in Tondeur et al. [31])	To develop a survey instrument based on a conceptual model structured according to concentric circles	The instrument consists of five dimensions
	Mooij and Smeets [33]	To conduct a study about modeling and supporting the aspects of ICT integration into Dutch secondary schools	Five models corresponding to successive phases for the ICT implementation and integration within schools
International comparative studies	Plomp, Pelgrum, and Law [34]	To conduct an international comparative study about the implementation and impacts of ICT in education toward the requirements and skills of the 21st century	A conceptual framework was developed
	Pelgrum [35]	To find out the obstacles by evaluating ICT integration in representative samples of K-12 schools	Obstacles caused by various aspects
	Kozma [36]	To examine technology and innovative classroom practices from 174 case studies in 28 countries	Concluded that ICT integration in classrooms helped change teaching and learning practices
	Wagner et al. [37]	To measure and evaluate the impact of ICT on school community members, including students, teachers, and schools	ICT can be utilized to initiate innovation in teaching and learning with new educational services
	Kozma [28]	To suggest a conceptual framework for policy-makers	The conceptual framework incorporates seven educational reform components

As shown by the literature review, when ICTs are integrated into schools, each resource should not be considered separately. In other words, when ICT4ED projects and ODA programs with the use of ICT in education are considered, it is essential to establish a fundamental framework that can provide educational practitioners and policy-makers with a tool to think about implementing ICT in education in alignment with other components of the educational system. This study also tried to determine the relevant components to be taken into account in ICT-enhanced classroom projects for developing countries.

3. Methods

3.1. Designing ICT-Integrated Learning Environments

In order to develop the framework for designing and constructing technology-enhanced K-12 classrooms in developing countries, the following procedures as shown in Table 2 were conducted in this study. We first conducted a literature review and extant case analyses of ICT4ED projects related to building technology-enhanced/ICT-integrated classrooms and teaching and learning activities, ICT-integrated classroom environments for schools in developing countries, data on extant classroom support projects, classroom models, and their effectiveness, and future classrooms research using advanced ICT.

Second, in order to elicit requirements and needs for ICT-integrated classroom projects in developing countries and the fundamental direction of developing ICT-integrated classrooms, in-depth interviews were conducted with eight experts involved in ICT4ED projects in developing countries. The criteria for selecting experts for the in-depth interview were the following. First, experts must have been involved in ICT4ED projects for more than five years. Second, experts must have expertise in educational technology, ICT, or computer science education (a PhD in such disciplines or working careers in such areas for more than 10 years).

Lastly, in accordance with the results of the literature review and extant cases and the findings of the in-depth interviews, we derived a conceptual framework for selecting ICT-integrated classroom models in developing countries.

Table 2. Research procedure.

Phase	Method	Research Activities
Analyzing previous literature and extant cases	Literature review	Analyzing previous studies on building technology-enhanced/ICT-integrated classrooms and teaching and learning activities Analyzing the factors of classroom environments and teaching and learning activities suitable for developing countries' schools
	Analysis of extant cases	Analyzing cases of extant classroom support projects, ICT4ED projects related to ICT-integrated classrooms, classroom models, and their effectiveness Analyzing future classrooms using advanced ICT Analyzing technology-enhanced/ICT-integrated classroom environments and teaching and learning activities in advanced classrooms in developing countries
⇩	⇩	⇩
Eliciting requirements and needs based on expert knowledge and experience	Constructing expert panel	Selecting and recruiting eight experts in academia and industry
	Conducting in-depth interviews with eight experts	Developing semi-structured and open-ended questionnaires for in-depth interviews Conducting in-depth interviews of around 100 minutes with each expert
⇩	⇩	⇩
Deriving a conceptual framework	Developing a conceptual framework from the findings	Eliciting factors to be considered for developing ICT-integrated classroom models tailored to the needs of developing countries. Developing a conceptual framework based on the above-mentioned research results

3.2. Participants and Research Setting

The eight experts who participated in the in-depth interviews have experience in constructing ICT-integrated K-12 classrooms or training teachers for ICT integration into the curriculum and

instructional methods with the use of ICT in developing countries. Table 3 shows the profiles of the experts. They have been involved in the ODA projects about ICT4ED by the government of the republic of Korea, through an international exchange cooperation. One of such ICT4ED projects is to build and support a pilot classroom with the use of advanced ICT based on Korean government's knowledge and experiences [38]. This project was initiated in 2011. Since then, ICT-integrated pilot classrooms including educational hardware and software and teachers' training to foster sustainable educational development were offered to more than 15 developing countries [38]. The participants recruited for this study have a wide experience of visiting such developing countries, meeting teachers, consulting on ICT integration in classrooms, and providing training courses throughout the project. The group comprised five university professors and three field experts. During the in-depth interviews, they commented on the challenges, constraints, and opportunities of creating ICT-integrated K-12 classrooms in developing countries.

Table 3. Experts' profiles.

Expert		Job	Academic Qualifications	Career (year)
Academic fields	A	Professor in an education department	Doctor of educational technology	10
	B	Professor in a computer education department	Doctor of educational technology	13
	C	Professor in a software engineering department	Doctor of communication engineering	13
	D	Professor in a computer education department	Doctor of electrical engineering	18
Practical fields	E	Deputy manager in a global infrastructure company	Bachelor of electronic engineering	15
	F	Manager in a global infrastructure company	Bachelor of electronic communication engineering	15
	G	Research team leader in a research institute of technology transfer to developing countries	Doctor of educational methods	13
	H	Teacher	PhD candidate in a computer education department	10

3.3. Research Instruments

For the in-depth interviews with the experts, semi-structured and open-ended questionnaires were used as instruments. The interviews were conducted between April and May 2018. The consent form was signed before the interview, following an explanation of the purpose of the interview. All the interview data were recorded and transcribed. During the interview, the experts were able to present implications and provide suggestions on the factors or criteria and methods for designing ICT-integrated learning spaces or classrooms based on their relevant experience and knowledge. A small benefit was given to the participants, except for the two experts (E and F) from a global infrastructure company. The following Table 4 shows the semi-structured and open-ended questionnaires for the in-depth interviews.

Table 4. Overview of questionnaires for the in-depth interviews.

Category	Questions
Understanding of technology-enhanced K-12 classroom projects	—Experiences on educational environment and classroom environment in developing countries —Advantages and disadvantages of ICT-integrated K-12 classrooms —Things to be considered most when building a classroom in developing countries —Opportunity factors for building classrooms in developing countries —Key factors of success and goals of building a classroom in developing countries —Factors affecting satisfaction and effectiveness of recipient countries and recipients
Discussing technology-enhanced K-12 classrooms for developing countries	—Classification criteria for constructing ICT-integrated K-12 learning spaces or classrooms —Things to be considered when building an ICT-integrated classroom to develop 21st century learner competency —Considerations for applying future-oriented teaching-learning methods —Other comments

3.4. Data Collection and Analysis

The research design for this study is situated in the interpretive paradigm as a qualitative analysis method. In-depth interviews with experts as well as extant case analyses based on prior literature review were used as data collection methods. In accordance with the interpretive research paradigm emphasized by Reeves and Hedberg [39], this study is concerned with the understanding of the ICT-integrated classrooms in the developing countries from the subjective knowledge and skills each expert has acquired through his or her experience. To put the analysis in an educational context, perspectives of stakeholders and users such as policy-makers, teachers, and students about the factors that could influence the successful use of ICT in their classrooms were interpreted.

The collected data of the in-depth interviews with experts were subjected to a three-step analysis of protocol reading, coding, and topic generation. The first stage consisted in reading the subjects. All interviews were transcribed, and the co-researchers read the transcriptions repeatedly. Second, for coding, this study relied on open coding and axial coding in grounded theory [40]. As the contents of the collected data were read and repeated several times, work was carried out to distinguish contents with meanings consistent with the purpose of the study and those without. We then proceeded to the conceptualization phase, by naming the contents and meanings frequently repeated in the text and judging their significance. At this time, the researchers tried to find expressions to clarify the meaning without changing the meaning of the content as stated by the participants. Through this process, concepts and their related sub-concepts or fields were categorized. Third, we created themes based on the results of the previous steps to determine related or similar categories. These organizational contents were finally described by the researchers. To ensure the validity of the data, triangulation was performed [41,42].

4. Factors to Be Considered when Developing ICT-Integrated Classroom Models

As a result of analyzing the in-depth interviews with eight experts, six categories of factors for designing ICT-integrated K-12 classrooms in a developing country were found: status and policies in ICT education, ODA goals and priority setting, selection of schools, infrastructure and technical challenges, pedagogical methods, and educational resources.

4.1. Status and Policies in ICT Education

It was found that the experts recognized that the direction and effects of ICT-integrated classrooms might be different depending on the current status of ICT education policies in the countries. In particular, experts stated that the education policy on such factors as the teacher's status and roles could influence forming the social culture of the country for ICT in education.

> "Perspectives and thoughts about the teaching profession are so different. For example, after teacher training, teachers might retire from teaching and go to work as a bank teller to earn more money. Teachers' salaries are so low that learning English and computers through ICT teacher training can lead to the unintended phenomenon that teachers discover high-paying careers." (B)

However, in reality, it is difficult to understand the current state of ICT education policies in developing countries. Therefore, it is necessary to guide the direction of their education and support the formulation of education policies.

> " … … difficult to pinpoint the current state of ICT education policies and to establish appropriate national policies. In this respect, donor countries need ICT education policy consulting to a beneficiary developing country." (C)

> " … … necessary to discuss whether educational policy should aim at improving short-term academic achievement or long-term educational effects." (G)

4.2. ODA Goals and Priority Setting

Experts also shared the common view of the need to carefully consider the aims and directions of ODA projects. They all stated that it is important to clarify the objective of the ODA project, determine the direction of the ODA project, and establish the host organization in the beneficiary developing countries. In particular, experts A and G emphasized that the objectives of the ICT-integrated classroom should be aligned with the objectives of the beneficiary country, and that the focus of the ODA project should be more concise and clearer.

> " … … . essential to decide whether ICT-integrated classrooms in the partner country aim at the educational effect in the short-term period or in the long-term period" (G)

> "Rather, it is more an opportunity to show the future of education in the era of the 4th Industrial Revolution through an advanced classroom model." (A)

> "Too many business goals of ODA may be ineffective. It is necessary to focus clearly on high-tech business and concentrate on them." (B)

The experts emphasized that it is necessary to coordinate and cooperate with ODA projects carried out in one country for sustainability, and it is stated that sustainability can be improved when a P-P-P (Public-Private Partnership) model is applied in which various entities such as public corporations and private companies can develop a win-win approach. Therefore, it was discussed that ICT-integrated classroom projects also need to be considered as such a P-P-P model in a larger context for sustainability.

> "This is not a one-time project, but it is necessary to maintain the relationship. For developing countries, I think it is very important to make best practices and models for beneficiary countries." (A)

4.3. Selection of Schools

Experts argued that the problems and issues to be tackled might be different depending on the school of the partner country in which ICT-integrated classrooms will be built, since the environment, infrastructure, community culture, and regional characteristics are very different. Most of the experts admitted that the selection of the school might involve linkages with political and economic forces.

> " … … … ..the economic and political gaps between the regions are large. In the tourist areas, Wi-Fi and other infrastructures are well equipped. In contrast, in the case of non-tourist areas … … .." (A, B, C)

> "If an atmosphere of working together to develop the school through linkage with the community around the school is formed, there is a greater chance … ." (A)

4.4. Infrastructure and Technical Challenges

In order to prepare for ICT-integrated classrooms, the status of infrastructure construction of a given developing country is very important. Most of the experts commented that electricity and network accessibility are the most basic and essential elements, and that the least developed countries are forced to focus on building ICT-integrated classrooms in urban areas. In addition, when building an ICT-integrated classroom, it was mentioned that environment factors such as the weather, temperature, and light of the country need to be taken into consideration.

> "Lightning is an environmental factor that can affect all infrastructures." (E, F)

> "considering the problem of humidity as well as the heat problem when using air conditioners and other machines." (E, F)

A number of experts claimed that it would be questionable whether ICT-integrated classrooms would be built with state-of-the-art infrastructure in the new space. If we consider the budget, period, and resources of the related project as a whole, the most realistic measure is to build an environment where teachers can easily download or utilize educational materials, even it they are not accessed on the internet.

> "It is not clear what the state-of-the-art infrastructure-oriented classroom model should do and what it is to do for what purpose." (E)

It was emphasized that infrastructure with the most up-to-date specifications as well as with the fundamental educational functions should be considered from a sustainable perspective. If state-of-the-art technologies are to be integrated, teacher training should also be taken into account in alignment with pedagogical methods.

> "There is no know-how about how to use it or how to teach it. … … … .including basic digital literacy competencies … While you are in training, I think it is necessary to be able to utilize it as a basic model and to have a future-oriented mind." (A)

All experts pointed out that maintenance is as important as building infrastructure. It can be seen that maintenance and security difficulties are spreading everywhere.

> "In the case of solar schools, it could be a brilliant idea in terms of schools that lack power, but in rural areas there are no paved roads, so there is a lot of dust and the panels are covered with fine dust … ." (C)

> "The advantage of a laptop is to be used without a battery, but maintenance is costly." (H)

> "The center where equipment maintenance can be done is not nearby." (B, C, E, F)

> "observed that an ICT-integrated classroom was rarely utilized because they are worried about the security of the device and maintenance." (B)

Therefore, more systematic and concrete maintenance plans should be presented at the time of construction. Infrastructure maintenance can be considered both inside and outside the school.

> "To solve the problem of infrastructure maintenance, the know-how of the hardware related to operation management should be handed on … ." (B, C)

4.5. Pedagogical Methods

Most experts pointed out that ICT-integrated classrooms need to be prepared to meet the requirements of developing-country schools regarding teaching and learning methods. It was emphasized that it is necessary to cope with the fact that the teaching and learning situation is very different for each country. Therefore, understanding the present situation and requirements of the teaching and learning aspects of the country may determine the success or failure of ICT-integrated learning.

> "The teaching-learning model in each of the current schools in developing countries is mostly lecture-based" (G)

> "varied range of examples from the most basic multimedia education to video conferencing and software education for developing countries to be interested in. Therefore, it is necessary to consider an integrative classroom model that can cover both the most basic teaching-learning model and the most advanced." (A, E, F)

Some experts stated that developing countries also need ICT-integrated education models for innovation and creativity in order to secure national competitiveness in the 4th Industrial Revolution. In other words, it is necessary for designs to proceed from a very basic education model to an advanced education model for effective application in classrooms. In order to apply these various levels of the education model to ICT-integrated classrooms, experts argued that improving the competence of the teachers would be the most important measure.

> "education using ICT should be modeled as a tool that leads to innovation and creativity to prepare for the future." (A)

> "necessary for the teachers (especially retired teachers) of donor countries to stay with them and transfer the knowledge over a long period." (A, C)

4.6. Educational Resources

It was pointed out that there is a lack of educational resources or materials for ICT-integrated learning in developing nations' classrooms. Even if there are many good open educational contents (OERs) on the internet, it is difficult for developing countries to download them due to network problems. To solve the problems, it was suggested that such OERs should be saved on the server or shared via the intranet. Furthermore, it is more effective to develop multimedia contents and teaching and learning materials in their mother language.

> "It seems to be feasible to help them store good materials on hard disks and install them via the intranet. It takes a long time to download data such as multimedia resources from the internet" (G)

> "In addition to English, we need to translate it into local native language. No matter how good OERs and software in English are, they are rarely used." (B, C)

5. The Conceptual Framework for Developing ICT-Integrated Classroom Models

Based on the requirements and needs elicited from the analysis of the in-depth interviews with the eight experts as summarized in Table A1, we will discuss recommendations for ICT-integrated classroom projects related to ICT-integrated classrooms.

First of all, it was revealed that it is most important to recognize and diagnose accurately the current policy status of the country in terms of ICT use in education. At the beginning of the interview, most of the experts described educational environments and problems with lack of physical and human resources in each country and then discussed how the ICT-integrated classroom would be designed

according to the educational status and teachers' capabilities. UNESCO [11] divided the educational policy status into four stages based on a knowledge ladder. CERI [43,44] divided the process of systemic innovation into three phases: initiation, implementation, and scaling-up. Fullan [45] also divided the educational change process into three steps: initiation, implementation, and institutionalization. Depending on the current stages and planned goals, the educational objectives and approach can be diagnosed and decided. The diagnosis of the current policy status can provide policy-makers and stakeholders of ODA with indicators about the curriculum, pedagogy, teachers' capabilities, and current educational status with ICT use.

Second, the specific aim of the project in accordance with the current policy status and future planned policy goals of the partner country's government should be firmly established at the beginning. The future planned policy goals and educational objectives to be achieved from the ICT4ED projects, based on the diagnosis of the country's policy stage, can give a hint about the proper direction of the educational approach. Some countries might anticipate the effectiveness of the project in short-term milestones. However, other countries might evaluate the results from a long-term perspective. Jhurree [46] emphasized that needs assessment and implementation plans customized for such requirements and willingness should be pre-produced to integrate ICT into education. Levine [47] also proposed procedural steps for effective ICT integration, the first of which is to formulate the visions, goals, and objectives based on data collected and analyzed by the planning team. In fact, from the interviews, depending on whether the experts judged the policy goal of the country related to the integration of ICT in education based on long-term or short-term milestones, they evaluated the effectiveness of the projects as negative or positive. Therefore, the detailed plans and the approach to ICT implementation in the classroom should be prepared based on the partner country's clearly defined vision and goals.

Third, as clearly defined policy goals serve as an indicator to promote decision-making regarding the educational objectives, what is necessary for what the country would like to achieve through ICT use in education should be elicited. In a modern society, developed nations have made great efforts to practice student-centered instructional methods to develop 21st century learning skills for human resources to prepare for the 4th Industrial Revolution [11]. However, some experts doubted that improving 21st century learning skills and student-centered instruction should be implemented in developing countries, since many children do not even have the opportunity to be educated through a teacher-centered approach. In this respect, it is crucial to identify the most adequate learning objectives with specific competencies to be achieved by the country through the ICT4ED projects. This can also help decide what kinds of competencies teachers should be inculcated with regarding the use of ICT in their education.

Fourth, based on the planned competencies for teachers and students, the teaching and learning methods to be promoted through the design of ICT-integrated classrooms in a specific partner country should be determined. As discussed above, the policy goals influence pedagogy and practice regarding the use of ICT. Lim [48] insisted that the use of technology in education shapes pedagogical methods and activities. To develop a specific competency for students, the teacher's professional development should also be planned in line with such purposes, and educational programs should be implemented in a coherent way [24]. In fact, in the interviews, some experts argued that it might not be effective to integrate state-of-the-art technology into teaching in developing countries and that a student-centered pedagogical approach might not be appropriate due to the lack of resources. However, others explained some of best practices for the integration of ICT, such as computer science education and innovative teaching approaches with conferencing systems in developing countries. One expert said that a classroom with advanced technology can be a showcase of future classrooms for the country.

As Harvey and Kenyon [49] insisted that classroom environments and furniture, including seating arrangements, are important factors in promoting active and collaborative learning, instructional methods and strategies through ICT might be closely connected to the design of the classroom and details of the resources for ICT integration. Therefore, it is crucial to establish the main instructional

methods and strategies based on the curriculum and learning objectives before deciding the design of the classroom and the resources to equip it with.

Fifth, the professional development programs for teachers should be designed based on the planned teaching methods and learning activities. As experts stated, the most serious problems with ICT integration in developing countries are that teachers are not capable of applying such technology and have little experience using ICT in the most effective and efficient way. Unwin [24] stated that most ICT integration in African countries failed, since they did not pay attention to teachers' involvement and training. Jhurree [46] also emphasized that teachers' participation can maximize the ICT integration process.

As shown in the results, all the experts discussed the technical problems and infrastructure challenges in developing countries. Indeed, technical aspects and infrastructure are the fundamental issues for ICT integration in education. Unwin [24] suggested that the sustainability of ICT4ED programs in terms of budget, infrastructure, software, and maintenance should be built into the plans from their inception. The limitations and challenges of the physical and human resources in the country should be truly and clearly recognized and diagnosed at the very beginning. More importantly, the stakeholders should plan how to achieve sustainable results by considering long-term operations based on such limitations and challenges. The design guidelines of the classroom related to the hardware and infrastructure suggested for the sustainability of the ICT-integrated classroom projects drawn from the interview will be summarized at the end of this section.

Finally, based on the recommendations above, we suggest a conceptual framework for developing ICT-integrated classroom models that provides practical guidance on the criteria for selecting which type of ICT-integrated classroom models might be appropriate when tailored to each partner country's environments and situations. As analyzed from both the relevant literature and the empirical data of the expert interviews, the process of implementing ICT-integrated classrooms should consider and integrate a variety of indicators to best reflect the diverse environments and needs of the partner country. Therefore, to build the conceptual framework for developing ICT-integrated classroom models tailored to each developing country's environments and situations, the framework was developed based on the model framework developed by Kozma [29] for consultations with the beneficiary partner country and its priorities. The structure of the framework consists of key influential elements according to the partner country's policy stage shown in Table 5.

This conceptual framework can "play a trajectory of coordinated, progressively higher forms of change that over time transform the education system" (p. 23), as Kozma [29] explained regarding his conceptual model. Each step is a complementary approach to the previous step; for example, Step 2 is complementary to Step 1, so that the approaches and environments in Step 2 are inclusive of those in Step 1. Furthermore, this framework can be used as a decision-making tool for ICT-integrated classroom projects. In this respect, Kozma [29] also recommended that the projects lead from a lower step toward a higher step to achieve educational transformation and innovation for the partner country's economic and social advancement.

After selecting a specific ICT-integrated classroom model based on the two-dimensional factors shown in Table 3, the facility and software appropriate for each step can be chosen depending on physical resources, including space and budgets. Overall, it can make up a three-dimensional framework.

Table 5. Conceptual framework for designing ICT-integrated classrooms in developing nations.

Criteria	Step 1	Step 2	Step 3	Step 4
ICT Education Policy Status	Preparation	Initiation	Implementation	Expansion
Education Goal	Knowledge Understanding	Knowledge Acquisition	Knowledge Deepening	Knowledge Creation
Using ICT in Education Goal	3R (Reading, Writing, Arithmetic)	Remembering and Understanding	Applying and Analyzing	Evaluating and Creating
ICT-Integrated Classroom Project Goal	[Short-Term goal] Know-how and experience transmission about ICT use in education	[Short-Term goal] Knowledge-building and improving skills about ICT use in education	[Mid-Term Goal] Integrating the knowledge and skills by building their own models about ICT use in education	[Long-Term Goal] Building future educational plans on human resources and demonstrating model schools using ICT in education
Learner competency	Basic literacy	Logical reasoning and Analytical thinking	Critical thinking and Collaborative problem-solving	Creative problem-solving and Computational thinking
Pedagogical methods	Drill and practice Reading, Writing, and Arithmetic	Lecture Discussion	Situation learning Project/ Problem-based learning	Inquiry-based learning Creative Problem-solving learning
Suggested Classroom Model	Classroom model 1	Classroom model 2	Classroom model 3	Classroom model 4

6. Conclusions

This study has attempted to find out factors to be considered when developing ICT-integrated classroom models, suggesting a conceptual framework for selecting the more appropriate classroom models tailored to the environments and needs of each developing country. This study conducted in-depth interviews with experts who have experience in ICT4ED projects and knowledge of integrating ICT into K-12 classrooms in developing countries. Through the analysis of the interviews, we deduced many factors to be taken into account when integrating ICT in various educational contexts of developing countries, and categorized them into five groups: status and policies in ICT education, ODA goals and priority setting, infrastructure and technical challenges, pedagogical methods, and lack of educational resources. Based on the recommendations elicited from the five categories, we suggest a conceptual framework that provides practical guidance on the criteria for selecting more suitable classroom models customized to each partner country's environments and contexts. The conceptual framework was developed based on the model framework suggested by Kozma [29] for consultations on the priority setting of UNESCO's partner countries. The framework promotes the decision-making of classroom design and priority setting, including pedagogical methods based on the diagnosis and evaluation of the partner country's ICT education policy status, education goals, goals for using ICT in education, ICT-integrated classroom project goals, learner competencies to be pursued, and the main pedagogical methods to be adopted.

This study offers a conceptual framework for considering and integrating a variety of indicators to best reflect the diverse environments and needs of the partner country. The framework can serve as a fundamental basis for evaluating diverse factors impacting ICT4ED projects and making tradeoffs between different priorities of stakeholders and different parties in the project. It is a very flexible tool leading to progressively higher forms of education with sustainability, by reflecting the changes and transition of the partner country's environments and contexts [29].

Nonetheless, there are some limitations to be treated in future research. First, since interpretive research is highly dependent on participants, the latter should be equally credible, knowledgeable, practically experienced, and unbiased in their field. Indeed, the interpretive paradigm as the basis of this qualitative research was helpful for exploring the conceptual framework of the criteria for selecting classroom models tailored to the educational environments and needs of each developing country. In addition, the authors in this study tried to recruit experts with diverse academic backgrounds and considerable experience of ODA projects and teacher training in ICT education. However, we would recommend that future studies adopt data source triangulation methods in qualitative research, such as interviewing stakeholders and users (teachers and students) in developing countries and observing ICT-integrated classrooms to improve the validity of the results. Second, this study presented a conceptual framework, but, in the future, it should be evaluated in real contexts from a practical perspective. The details of the factors and criteria of the conceptual framework should be revised and polished through the application to practical contexts and improved in terms of the design specifications, including facilities, resources, hardware and software, and even desk and seating arrangements in each classroom model. Lastly, a micro-level perspective of ecology in developing countries' primary and secondary schools should be considered. Seeing that the conceptual framework suggested in the current study was developed mainly based on national policies, status, and environments as a macro-level perspective, teacher motivation and users' factors might have been overlooked. For instance, the teacher support systems proposed by Yuchi, Jing, and Endris [50] can impact teachers' perception and technology integration into teaching and learning contexts by increasing their intrinsic motivation. This means that to assess the integration of technology in their instruction, the teacher levels of the Technological Pedagogical Content Knowledge (TPACK), which refers to multilateral forms of knowledge, should be considered [51,52]. Furthermore, along with intrinsic motivation, extrinsic motivations for teachers—such as salary, incentives, benefits and promotions, and establishing social networks for positive collaborations with community partners—might be one of the crucial factors to be taken into account.

To prepare globally competitive human resources in developing countries, Kozma [29] emphasizes that the implementation of ICT in education should be considered in a broader context of economic development goals and social roles. When ICT is integrated into education in alignment with all the components of the education system, economic advancement and social development can be achieved, and the ICT4ED projects and programs can contribute to educational transformations in developing and less developed countries.

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Appendix A

Table A1. Qualitative supporting data from experts in each category and factor.

Categories to be Considered	Factors to be Considered	Qualitative Supporting Data from Experts
Status and policies in ICT education	The education policy such as the teacher's social status might influence on ICT in education projects.	*"One of the things about this country requiring caution is that the K-12 school and classroom environment is quite different. Perspectives and thoughts about the teaching profession are so different. For example, after teacher training, he or she might retire from teaching because of low pay and go to work as a bank teller to earn more money. Teachers' salaries are so low that learning English and computers through ICT teacher training can lead to the unintended phenomenon that teachers quit teaching job and discover high-paying careers." (Expert B)*
	It is necessary to guide the direction of their education policy.	*"It is difficult to pinpoint the current state of ICT education policies in developing countries and it is difficult to establish appropriate national policies. In this respect, donor countries need ICT education policy consulting to a beneficiary developing country." (Expert C)* *"It is necessary to discuss whether educational policy for developing ICT-integrated classrooms should aim at improving short-term academic achievement or long-term educational effects." (Expert G)*
ODA goals and priority setting	The objectives of the ICT-integrated classroom should be aligned with the objectives of the beneficiary country and that the focus of the ODA project should be more concise and clearer	*"It is essential to decide whether ICT-integrated classroom in the partner country aim at the educational effect in the short-term period or in long-term period" (Expert G)* *"I doubt whether the education of the country can actually improve the current education because one advanced classroom is built. Rather, it is more an opportunity to show the future of education in the era of the 4th Industrial Revolution through an advanced classroom model." (Expert A)* *"Too many business goals of ODA may be ineffective. It is necessary to focus clearly on high-tech business and concentrate on it." (Expert G)*
	ICT-integrated classroom projects need to be also considered as such a P-P-P model in a larger context for sustainability	*"This is not a one-time project, but it is necessary to maintain the relationship. For developing countries, I think it is very important to make best practices and models for beneficiary countries, rather than simply taking advantage of ICT in one school, in terms of enhancing sustainability." (Expert A)*
Selection of schools	The selection of the school might involve linkages with political and economic forces.	*"In the developing countries, the economic and political gaps between the regions are large. In the tourist areas, Wi-Fi and other infrastructures are well equipped. In contrast, in the case of non-tourist areas, almost no infrastructure is available, so selecting a school in that country can influence the direction and construction of high-tech classroom projects." (Expert A, B, C)* *"If an atmosphere of working together to develop the school through linkage with the community around the school is formed, there is a greater chance to achieve the successful ICT-integrated learning." (Expert A)*

Table A1. *Cont.*

Categories to be Considered	Factors to be Considered	Qualitative Supporting Data from Experts
Infrastructure and technical challenges	The environment such as the weather, temperature, and light of the country needs to be taken into consideration.	*"Lightning is an environmental factor that can affect all infrastructures." (Experts E, F)* *"We should think about the classroom environment considering the problem of humidity as well as the heat problem when using air conditioners and other machines." (Experts E, F)*
	The most realistic measure is to build an environment where teachers can easily download or utilize the educational materials accessed without the internet.	*"Considering issues such as budget and time, we need to think about various ways of building ICT-integrated classrooms, for instance, renovation of existing classroom environments." (Expert D)* *"It is not clear what the state-of-the-art infrastructure-oriented classroom model should do and what it is to do for what purpose." (Expert E)*
	teachers' training should also be taken into account in alignment with pedagogical methods.	*"There is no know-how about how to use it or how to teach it. It is necessary to take an innovative model that can induce the sustainable use including basic digital literacy competencies . . . It gets old after two to three years and becomes a regular lab level, so you might only be able to show the advantages of advanced classrooms for at least one to two years . . . While you are in training, I think it is necessary to be able to utilize it as a basic model and to have a future-oriented mind." (Expert A)*
	. It can be seen that maintenance and security difficulties are spreading everywhere.	*"In the case of solar schools, it could be a brilliant idea in terms of schools that lack power, but in rural areas, there are no paved roads, so there is a lot of dust and the panels are covered with fine dust, which makes it difficult to use solar efficiently." (Expert C)* *"The advantage of a laptop is to be used without a battery, but maintenance is costly. The use of pads is in the same situation. In addition, the projectors are more cost-effective than electronic boards in developing countries." (Expert H)* *"The center where equipment maintenance can be done is not nearby." (Experts B, C, E, F)* *"In a foreign school of Mongolia, I observed that an ICT-integrated classroom was rarely utilized because they are worried about the security of the device and maintenance." (Expert B)*
	Infrastructure maintenance can be considered both inside and outside the school.	*"To solve the problem of infrastructure maintenance, the know-how of the hardware related to operation management should be handed on, and the hands-on experience of ICT directors and other teachers encouraged." (Experts B, C)*
Pedagogical methods	Understanding the present situation and requirements of the teaching and learning aspect of the country may determine the success or failure of ICT-integrated learning.	*"The teaching-learning model in each of the current schools in developing countries is mostly lecture-based. Therefore, an advanced classroom model needs to be built in consideration of the current or target educational goals of developing countries." (Expert G)* *"There are a varied range of examples from the most basic multimedia education to video conferencing and software education for developing countries to be interested in. Therefore, it is necessary to consider an integrative classroom model that can cover both the most basic teaching-learning model and the most advanced." (Experts A, E, F)*

Table A1. *Cont.*

Categories to be Considered	Factors to be Considered	Qualitative Supporting Data from Experts
	Improving the competence of the teachers in terms of pedagogical methods would be the most important measure	*"If it is to simply help education without using ICT, it is right to increase the efficiency and effectiveness of education at present. However, education using ICT should be modeled as a tool that leads to innovation and creativity to prepare for the future." (Expert A)* *"It is necessary for the teachers (especially retired teachers) of donor countries to stay with them and transfer the knowledge over a long period." (Experts A, C)*
Educational resources	It is more effective to develop multimedia contents and teaching and learning materials in their mother language.	*"It seems to be feasible to help them store good materials on hard disks and install them via intranet. It takes long time to download data such as multimedia resources from the internet, so it is necessary for a teacher to download useful content and consider using it with several teachers." (Expert G)* *"In addition to English, we need to translate it into local native language. No matter how good OERs and software in English are, they are rarely used." (Experts B, C)*

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