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The Influence of Teachers' Professional Development Activities on the Factors Promoting ICT Integration in Primary Schools in Mongolia

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Abstract: This paper examines the influences of professional development activities on important teacher-level factors that are important for the use of Information and Communication Technology (ICT) in education for primary school teachers in Mongolia. The study utilizes the survey data collected in 2012 (n = 826) and 2016 (n = 1161) to identify the changes in factors that are important to the use of ICT in education. The study result shows that six teacher level factors that are important for the ICT integration have been improved over time through professional development activities. These are professional competency in educational use of ICT, collaboration for ICT integration, benefits on use of ICT, autonomy to innovate, recognition as a professional, and skills and practices in educational use of ICT. This provides supporting evidence to educational practitioners for the implementation of effective professional development programs to promote ICT integration in education, especially in the developing country's context.

Keywords: teacher's professional development; education policy; educational change; ICT in education; factors promoting ICT integration

1. Background

1.1. Quality Education and Teachers' Professional Development with ICT

Promoting quality education has been a primary focus globally in achieving sustainable development, which is emphasized in Sustainable Development Goal (SDG) 4 that aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" [1]. Understanding educational quality requires a holistic approach, which should consider multiple aspects such as learner characteristics, teaching and learning processes, learning outcomes, and contextual factors [2]. Among all the aspects, the quality of teachers is a critical indicator of educational quality. Previous studies have provided solid evidences that the quality of teachers directly relates to the quality of education delivered, and to the learning outcomes of the students o a basic education level [3–5]. Therefore, one of the major targets to achieve SDG 4 is to substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing states.

Information and Communication Technology (ICT) has developed rapidly and taken up significant roles in promoting aspects of quality education, such as the access and inclusion of learning opportunities, quality learning, and lifelong learning pathways [6]. On a basic education level, ICT has

evolved from being part of the school curriculum to being pervasively used as the tool in facilitating classroom teaching. Specifically, Becker [7] examined whether computers are compatible with the requirements in teaching, where he illustrated the evolution of ICT in education from skill-oriented subject learning to being part of the instructional method. In practice, a number of cases from different locations in the world reported the importance of ICT in promoting student-centered education [8–13]. For example, Education Audiovisual and Culture Executive Agency highlighted the use of ICT in promoting innovative teaching methods. Specifically, using ICT for project-based learning activities that engage students in open-ended problem solving, and also using ICT for personalized learning, where students learn in ways relevant to their background, experiences, and interests [10]. With the emergence of new ICT tools to promote quality education, it is vital to focus on capacity-building for teachers in integrating ICT in education [14]. This is because merging ICT with pedagogies requires a different set of skills of teachers to manage the classroom and enhance the learning environment [15].

On the one hand, ICT has been emphasized to be included as part of the training contents in teachers' professional development. On the other hand, it has also been actively utilized for teachers' professional development. ICT has been utilized as an important tool to support distance learning and to facilitate self-learning in regions where the organization of professional development centrally is challenging [16]. There are different fashions to support teachers' distance learning through using ICT, for example, the use of CDs to record video materials showing classroom practices helps teachers to improve their pedagogical knowledge and reflect on their own practice [16]. More recently, the internet has been utilized to provide educational contents, mostly in the format of video [17]. There are also multiple successful and established online platforms such as Coursera which provides a comprehensive learning experience to remote learners. With the rapid development of Web 2.0, teachers are gaining interest in using applications such as blogs, podcasts, and forums, where teachers have the opportunity to aggregate threads of discussions, and synthesize and analyze various topics [18]. These applications show that ICT is a popular tool to support teachers' professional development under multiple settings.

1.2. Mongolia Country Background and Its ICT Polices in Education

Mongolia is a landlocked country situated between Russia and China, which is one of the world's most sparsely populated countries with approximately 1.6 million km^2 land size and 3 million population [19]. During the 1990s, Mongolia experienced a relatively peaceful democratic revolution with the dissolution of the Soviet Union [19]. The country has a multi-party system with a new constitution from 1992 and the transition to market economy. This has led to many changes in people's lives, and the history has proved that the county achieved rapid and successful transition to the democratic system [20]. Under this historical background, the Mongolian education system has experienced a major transition from a centrally planned system to a decentralized system since the 1990s. It resulted in increased roles and responsibilities for local governments and schools. With such major changes, school managers and teachers in rural schools have faced difficulties. The specific issues include a lack of quality teacher training, limited budget, and gaps in education quality between rural and urban schools [21]. In order to address the need for change in public schools in Mongolia, the government has allocated funds through policy implementations, especially for rural schools.

Given the circumstance that basic infrastructure such as electricity being accessible in every province of Mongolia, recent policies are focusing on the introduction of student-centered approach and teacher training using ICT. Specifically in primary education sector, Ministry of Education, Culture, Science and Sports (MECSS) issued "New Education Standard" in 2003 to promote the concept of student-centered education in the school curriculum [22]. From 2014, the "Core Curriculum", which specifically guides primary school teachers to apply student-centered education is being employed [23]. Regarding the introduction of ICT, the "Master Plan to Develop Education of Mongolia in 2006–2015" formulated policies to integrate ICT in classroom teaching and teacher training activities [24]. The Master Plan has emphasized the importance of incorporating ICT into teacher training as part of the quality assessment for educational development, as well as initiatives in

connecting rural schools with internet and the provision of ICT equipment on a school level. With this policy guidance, there is a growing interest among teachers to actively develop and utilize different ICT tools in educational activities. After the legislative document ICT Vision-2010 was approved by the Parliament of Mongolia, ICT Vision-2010 in the Education Sector was approved by MECSS which lays out specific objectives, targets and resources to support schools. Further, the Policy of ICT in the Education Sector (2012–2016) formulated the policy to improve the continuous professional development of teachers through national teacher training platform [25]. More recently, ICT in Education Policy Action Plan (2012–2016) specified the plans to renew teacher training programs in accordance with latest ICT development as well as new education standards and curriculums [26]. As a practical response to these initiatives, the MECSS of Mongolia established the web-portal for promoting the utilization of electronic and interactive learning contents since 2015 [27]. From 2016, the government included the use of ICT as a tool to promote lifelong learning in the Basic Education Plan (2016–2020), specifically stating that the "training of lifelong learning skills using ICT as a learning tool will contribute to solving regional education issues."

1.3. Project Activities on Educational Use of ICT in Mongolia

With the government policy emphasizing on the development of ICT in education, multiple ICT related projects were conducted in the Mongolian education sector through cooperation with the Mongolian government and bilateral organizations. In 1990s, the Gobi Women's project was initiated in 1992 and completed in 1996, responding to the new trend of living and learning needs for the majority of the population, including the population in rural areas. The women of the Gobi desert were identified as being the most in need of learning opportunities. Radios and radio programs played a significant role in the project to deliver information to the most remote populations. By 1996, thousands of women from the Gobi desert were taking part in learning activities offered through radio, printed material, and the support of visiting teachers [28].

The ICT for Innovating Rural Education of Mongolia (IIREM) by the Asian Development Bank (ADB) was conducted during 2004 to 2006 to establish a replicable model for using ICT content to bring educational content and modern pedagogy to rural schools and communities in need. The project has demonstrated how ICT, mainly electronic educational materials in the format of compact disks (CD) could help rural teachers to teach with a more student-centered learning approach. It has also demonstrated the utilization of laptop computers with email as a communication tool to enhance school administrative system in terms of efficiency and transparency [29].

The One Laptop per Child (OLPC) project was introduced in Mongolia in 2008. The project aimed at providing every child with one laptop by the year 2010. The project served as a tie for international volunteers, local teachers, students, and parents to make the implementation of OLPC meaningful. Teachers were using OLPC to optimize the effects of it on student learning, by designing lessons using OLPC with adherence to the curriculum. Teachers were also able to learn practical computer skills from this project [30].

The Tokyo Institute of Technology conducted the grassroots project in improving the quality of primary education between 2012 and 2017 in rural Mongolia [31]. The general aim of the project was to let rural teachers produce digital teacher training materials that reflected local characteristics, which was a need that had not been catered to by previous projects. Through this approach, teachers were expected to be equipped with both ICT and pedagogical skills to integrate technology with their teaching needs. Because the project aimed at improving the professional competency of the primary school teachers nationwide in sparsely populated Mongolia, the activities were organized through the cascade model. Provincial level educational administrators and mentor teachers were developed on national level first, who in turn organized provincial level training to disseminate the knowledge to local primary school teachers. The local teachers then formed teams to produce digital teacher training materials using ICT and disseminated the final materials to schools nationwide. This method provided opportunities to local teachers to conduct professional development through hands-on, collaborative

activities, which was considered more effective than that through lectures only. A total of 1650 primary school teachers participated in the teacher training programs mainly in five regions of Mongolia, which was approximately 22% of the total number of primary school teachers in Mongolia.

1.4. Study Objective

Through the review of current trends on quality education and educational use of ICT, it is clear that the teacher plays a key role in facilitating educational changes, such as adopting new pedagogies using ICT, and utilizing ICT for professional development. Mongolia is no exception, where the educational policies have been focusing on introducing new pedagogies and incorporating ICT for professional development of teachers and effective classroom teaching. Previous international development projects have also practically introduced ICT into teachers' educational activities. With this background, the objective of this longitudinal study is to analyze how teacher training programs focusing on ICT use in educational practices have had an influence on teacher level factors that are important for ICT integration in educational activities. The comparative data of 2012 and 2016 are utilized covering more than 800 teachers from five provinces in Mongolia. In order to achieve this objective, the following section reviews the relevant teacher level factors contributing to the integration of ICT in education.

2. Literature Review

Educational change has been discussed widely in supporting educational reforms, educational technology innovations and any other changes associated with transformation in educational policies. In general, educational change means alterations in the scope of the total educational endeavor, includes modification of curriculum, teaching methods, enrollment patterns [32]. During the course of the rapidly increased use of ICT in education, Fullan [33] pointed out the significant role of the teacher as the agent of change. Specifically, he argued that teachers need to equip themselves with new assets such as the competency to use technology to facilitate new pedagogies. Further, it is pointed out that teachers' belief in the use of ICT to achieve personalized lessons, professional capital through teamwork of teachers, and leadership to support innovations influence successful changes. As mentioned above, literature indicates that multiple aspects of teachers are important for the adoption of ICT in education as part of the educational change. The current study is interested in how professional development may influence teacher level factors that are important for the educational use of ICT. Therefore, the following section further reviews the literature on important factors for teachers' educational use of ICT with regards to professional development activities.

2.1. Professional Competency

Hayes [34] summarized three relevant principles of professional development aiming at improving teachers' professional competency. First, professional development activities should provide models of new practices connected to the classroom, rather than letting them think about principles and practices of teaching. Through the practice of teaching, educational theory is employed. An understanding of theory alone is insufficient as an agent of long-term change. Teachers need to be able to see the impact of the proposed innovation on daily classroom procedures if it is to have any validity. Morris [35] showed that the professional development attempting to integrate technology in education should show teachers the available tools and how they can be used to support the delivery of the curriculum. Furthermore, Korthagen [36] argues that professional development should connect teachers with practices and theories on the school level. It is important for teacher trainers to link their personal strengths with academic theories and educational practices derived from them. Second, teacher trainers should themselves be teachers. This is important because training contents should be grounded in the experience of a teacher colleague and is not the abstract theory of a ministry official or university lecturer, who are far removed from ordinary classrooms. Jung [37] reviewed the teacher development practice where ICT was adopted for teacher development, and emphasized the importance of using ICT for teacher trainers to facilitate continuous professional development. Third, in terms of teacher

development opportunities, activities that extend over time are more likely to allow teachers to try out new practices and receive feedback. Previous studies have found that the change in a teacher's educational practices is positively related to the intensity and duration of teachers' development activities [38]. Recently, Kartal et al. [39] provided evidence that continuous professional development activities sustained over a year were perceived to be more effective by teacher participants than short-term teacher development programs.

2.2. Collaboration and Sharing

Garet et al. [40] pointed out that teacher training programs focusing on lectures by the expert often has a limited impact in assisting teachers to adopt ICT and pedagogies. This form of professional development is criticized as being ineffective in providing teachers with sufficient time, activities, and contents to increase teachers' knowledge and foster meaningful change. Therefore, the continuous professional development for teachers and school principals that features mentoring, peer observation and coaching, and local study groups with specific subject matters is considered effective. Knowledge sharing and collaboration within schools are considered important change factors as teachers who work together have higher opportunity to discuss concepts and skills, and problems arise from professional development activities [40]. Beyond interacting with one's local cohort of teachers and administrators, professional development can involve engagement with networks of education professionals who exchange ideas about their shared practices and values. These interactions amplify a teacher's ability to question ineffective routines, engage in reflective dialogue, and examine new perspectives on teaching and learning. In the context of English writing instruction, Penuel [41] showed evidence of effective change in teachers' instructional practices when they receive help from the colleagues who benefited from the professional development. Voogt et al. [42] conducted the study on impact of teacher collaboration for designing curriculums and planning classroom activities as part of the teacher training practices. The study found that collaboration is particularly useful as collaborative activities allow teachers to interact with their peers to address their own needs, which translate designed curriculums into practice.

2.3. Skills and Practices on the Use of ICT

Teachers' acquisition of new skills and practices related to ICT use is another aspect of effective professional development. Different types of ICT skills, identified in the digital competence framework, include information literacy, communication using digital technologies, and the ability to resolve problems situated in digital environments [43]. Napal et al. [44] indicated the importance of developing teachers' ICT competencies with particular emphasis on information literacy and safety, as well as ability to create digital contents. Professional development activities provide opportunities for teachers to engage in observation, discussion, planning, and practicing new skills. The acquisition of new skills in the use of ICT can be carried out in multiple ways, such as observing model teaching and peer reviews, as well as hands-on practice to create digital contents and testing in the classroom teaching.

2.4. Perception on the Use of ICT

Cox et al. [45] found out that teachers are likely to use ICT in their professional work if they see the need to change their existing professional practices. He concluded that perceived usefulness is an important factor influencing teachers, the uptake of technology and thus ICT training program should include activities to ensure teachers are confident about the value of using ICT in their professional practices. Further, Drent [9] found out that the teachers who see the advantage of using ICT in the classroom are more likely to practice the use of ICT for student-centered education. Buabeng-Andoh [46] also reported that the positive perception of the teachers regarding using ICT in the classroom is a significant factor affecting their practices in using ICT for classroom teaching. In order to enhance the positive perception on use of ICT in education, Gudmundsdottir and Hatlevik [47]

recommend that teacher educators should serve as good role models, showing the exemplary use of ICT and ways to critically assess its appropriate use.

2.5. School Leadership Support

School leadership is considered an important contextual feature for teachers to succeed in professional development with the use of ICT [40]. This is particularly applicable in teacher development activities that attempt to integrate new practices such as the use of ICT for teaching and school management. Sheppard [48] identified three leadership styles in investigating the integration of ICT, namely, hierarchical, administrator centered, and collaborative. He found out that the most successful group of schools in successful use of ICT have collaborative leadership, an open vision, and the willingness to take risks. Also, the school with a successful use of ICT practice implements an inclusive policy in school management, involving teachers, parents, and other community partners. Bryderup and Kowalski [49] noted that formulating an ICT plan on a school level is a logical process in setting goals for stimulating and ensuring the use of ICT in educational contexts. Scrimshaw [50] illustrated that the leadership supporting informal collaboration between teachers on knowledge sharing is important in coping with the constant changes in technology. Teachers felt that being able to reach out to others reduces the anxieties about exposing a lack of certain skills. Lee and Nie [51] studied the teachers' perception on school leadership and found that behaviors such as delegating authority and providing individualized concern and support could empower teachers to be more active in school activities.

3. Research Design

3.1. Data Source

This study utilizes the data from two longitudinal surveys conducted in Mongolia as part of the grassroots project on teachers' professional development, described in Section 1.3. The survey instrument was developed by Mongolian education experts in collaboration with an independent research agency in Mongolia. The questionnaire instrument was tested, revised, and translated to cater to the contextual characteristics of teachers' professional development in Mongolia. Specifically, the study employs the baseline survey data of 2012 and impact survey data of 2016 to make a comparison on changes in factors that are important for teachers' integration of ICT in education. The baseline survey collected data from 826 primary school teachers (8.3% of the total) from four geographically distinct provinces and one district in the capital city of Ulaanbaatar. The impact survey collected data from 1161 teachers (11.6% of the total) of the same provinces and district in 2016. Population sampling was deployed to collect data from these five places reflecting diverse geographical locations. Data collection was authorized by the Education Culture Department (ECD) of each local government. The survey was distributed by post through ECD of each province and a city district and collected accordingly. For the purpose of comparison, the same set of questions were asked in both surveys consisting of three major sections. The first section included demographic information of the respondents, such as age, gender, and school location. The second section focused on teachers' perception on the current state of teacher training and on self-development practices at school levels. It also explored their perception of skills and abilities to develop and use training materials, and their ICT skills. Examples of questions include "I feel professionally competent as teacher because I can develop and use digital contents in my teaching" and "I think my skills for developing digital contents have improved". The third section incorporated a set of questions to enquire teachers' perceptions on school ICT infrastructure, collaborative work, perceived benefits on use of ICT, and various aspects of use of ICT in education. Examples of the questions are "I use ICT to make students more interested in different subjects and lesson contents", and "Teachers have an opportunity to make decisions that are relevant for their own teaching". All the responses were measured in a 4-point Likert scale

with 1 indicating strongly disagree and 4 indicating strongly agree. The collected data were analyzed using SPSS [52].

To support the interpretation of the data analysis result, monitoring missions took place in the same five regions where data were collected. The monitoring team consisted of local educational experts and the research team of the Tokyo Institute of Technology. The team conducted the semi-structured interviews with school principals and organized focus group discussions with primary school teachers. A total of 358 educational practitioners were interviewed, which included six provincial level education administrators, 24 school principals, 28 school training managers, 230 local primary school teachers, and parents. The interview and focus group discussion results were transcribed and analyzed through data coding, followed by categorization of the information. The categorized information was then refined and summarized by the monitoring team members. Specific examples were utilized to interpret and explain the quantitative analysis results.

3.2. Factor Analysis

The potential question items that could measure the corresponding characteristics of effective professional development are identified first. Since there are multiple items measuring each characteristic, factor analysis is conducted first to help understand whether the items are correctly placed under different characteristics and if not, what the correct groupings are. In particular, the Principal Component Analysis (PCA) technique is used for exploratory factor analysis. PCA is one of the factor analysis techniques that is designed for the dimension reduction for large multivariate datasets [53]. In this study, multiple survey items were hypothesized to measure certain factor categories for which the definition came from the literatures. However, this "matching by understanding" approach does not ensure the items are measuring one factor in a scientific way. Therefore, factor analysis serves as a tool to help scientifically determine whether those observable variables are measuring the same latent variable, and the results provide evidence to sort items accordingly, so that the constructed factors are unidimensional.

In terms of the result of factor analysis, the rotated component matrix in Appendix A shows that seven components can be extracted from a set of 39 questionnaire items. The criteria to decide the number of components to be extracted is when the eigenvalue of the component is greater than 1, which is the most widely used and accurate criteria for a moderate number of variables (20 to 30) [54,55]. The Varimax orthogonal rotation method is also used to assist interpretability. This method allows each principal component to load very high on a smaller number of items and low on other items, making the interpretation of the resulting factors (principal components) easier [54]. The threshold of component-factor correlations (factor loadings) to determine which variables should be retained for interpretation is not absolute, different studies or guidance use different thresholds of factor loadings varying between 0.4 to 0.8 [55–59]. Although there is no factor loading threshold that can be directly applied to the factor analysis in this study, current studies on factor loading pointed out that the sample size is the criterion to consider when deciding the appropriate factor loading threshold for a specific study. It is generally suggested that the component with four or more loadings above 0.6 are reliable, regardless of sample size, in addition, the component with few loadings may be interpreted given a sample size greater than 300 [55]. Based on this understanding, items in the component matrix in the appendix that have factor loadings greater than 0.6 are marked red. Meanwhile, it can be observed that each of the seven components has simple loading structure, i.e., each one of the 30 items load significantly (loading greater than 0.6) on a single principle component. As a result, 28 independent variable items can be categorized into seven latent variables. The following Table 1 is to show the constructing items of each latent variable, each consisting highly loaded items. The commonality of the underlying items of each latent variable was carefully analyzed and interpreted by the research team in collaboration with a Mongolian local education expert. The newly constructed variables were renamed reflecting the condition of primary school teachers' professional development in Mongolia.

The constructing items were then summated and averaged to create the latent variables, representing the factors that are important to the integration of ICT in education.

Table 1. Constructing items for the factors on integration of Information and Communication Technology (ICT) in education.

Constructing Items	Latent Variable
I feel professionally competent as teacher because I can develop and use digital contents in my teaching I feel professionally competent as teacher because I can operate ICT equipment in my teaching I am satisfied with my job as teacher because I can develop and use digital contents in my teaching I feel professionally competent as teacher because I develop and use digital teacher training materials I am satisfied with my job as teacher because I can operate ICT equipment in my teaching I am satisfied with my job as teacher because I develop and use digital teacher training materials I am satisfied with my job as teacher because I can use Scratch in my teaching I feel professionally competent as teacher because I have professional development opportunities	Professional competency in educational use of ICT
We work in a systematic way to develop teaching based on ICT There is a systematic sharing of pedagogical experience in use of ICT There are clear pedagogical goals for the school's ICT initiative School management supports us in understanding how the use of ICT can improve teaching I can use subject-specific digital teaching aids in my teaching	Collaboration for ICT integration
I think the support from school makes a progress towards student-centered education I think the use digital contents makes a progress towards student-centered education I think the use of ICT tool makes a progress towards student-centered education I think professional development opportunities make a progress towards student-centered education	Progress towards student-centered education
I use ICT to make students more interested in different subjects and lesson contents By using ICT, it is easier to motivate students I feel that ICT contributes to make my teaching more varieties	Benefits on use of ICT
Teachers have an opportunity to make decisions that are relevant for their own teaching School management believes I am a good teacher School management encourages me to try new ideas for teaching methodology	Autonomy to innovate
Do you think that your work as teacher is appreciated by the following constituents—Colleagues Do you think that your work as teacher is appreciated by the following constituents—Parents & Community Do you think that your work as teacher is appreciated by the following constituents—School management	Recognition as a professional
I think my skills for developing digital contents have improved I think the teachers in my school have ICT skills I think the use of blended teaching is spreading	Skills and practices in educational use of ICT

Following the factor analysis, Cronbach's Alpha is used to determine whether multiple items grouped based on the result of factor analysis are measuring the same scale. Cronbach's Alpha is a measurement of internal consistency which means how well the underlying items are measuring the scale, i.e., are multiple items measuring the same concept. Its value ranges from 0, meaning no internal consistency, to 1, meaning perfect internal consistency, a numerical value for Alpha above 0.7 is generally accepted [60,61]. In this study, seven latent variables were identified based on the results of PCA. Cronbach's Alpha is utilized to check the internal consistency of the items under each latent variable. Table 2 shows that the Cronbach's Alpha values for all seven latent variables are greater than 0.7, indicating that the constructing items for each variable are internally consistent.

Table 2. Cronbach's Alpha for latent variables.

Latent Variable	Cronbach's Alpha
Professional competency in educational use of ICT	0.892
Collaboration for ICT integration	0.855
Progress towards student-centered education	0.875
Benefits on use of ICT	0.873
Autonomy to innovate	0.764
Recognition as a professional	0.768
Skills and practices in educational use of ICT	0.800

3.3. Hypotheses

Reflecting the research objective to see the influence of professional development activities on teacher level factors that are important for ICT integration in educational activities, the following seven hypotheses in Table 3 are developed based on the factors identified in the factor analysis.

Table 3. List of hypotheses.

Hypothesis 1	Teachers' perception on professional competency in educational use of ICT increased between 2012 and 2016
Hypothesis 2	Teachers' perception on teachers' collaboration in use of ICT in education increased between 2012 and 2016
Hypothesis 3	Teachers' perception on progress towards student-centered education increased between 2012 and 2016
Hypothesis 4	Teachers' perception of the benefits on use of ICT increased between 2012 and 2016
Hypothesis 5	Teachers' perception on autonomy to innovate increased between 2012 and 2016
Hypothesis 6	Teachers' perception of their recognition as a professional increased between 2012 and 2016
Hypothesis 7	Teachers' perception on their skills and practices in educational use of ICT increased between 2012 and 2016

3.4. t-Test

Independent samples *t*-test is used to determine if a difference exists between the means of two independent groups on a continuous dependent variable. More specifically, it helps to determine whether the difference between these two groups is statistically significant. This test is also known by a number of different names, including the independent *t*-test, independent-measures *t*-test, between-subjects *t*-test, unpaired *t*-test and Student's *t*-test. In this study context, *t*-test is utilized to detect if there are any differences in teachers' perceived characteristics of effective professional development before and after the project intervention. The independent samples *t*-test tests the null hypothesis (H_0) and alternative hypothesis (H_1) as shown below.

$$H_0: \mu 1 = \mu 2 \text{ (means of two groups are equal)}$$

$$H_1: \mu 1 \neq \mu 2 \text{ (means of two groups are not equal)}$$

The null hypothesis is rejected when the significance test shows $p < 0.05$. In this case, alternative hypothesis is accepted which states that the means of the two groups are not equal. To select the valid

t-test result for interpretation, Levene's test for the equality of variances should also be investigated. Levene's test is also a hypothesis test as shown below.

$$H_0\text{: } \sigma_1{}^2 = \sigma_2{}^2 \text{ (the group variances are equal)}$$

$$H_1\text{: } \sigma_1{}^2 \neq \sigma_2{}^2 \text{ (the group variances are not equal)}$$

Null hypothesis is rejected when the significance test shows $p < 0.05$. In this case, equal variances of the groups cannot be assumed. Therefore, the Welch *t*-test result should be used for interpretation. In the opposite, the normal *t*-test result should be interpreted if null hypothesis is accepted.

4. Data Analysis Results

4.1. Descriptive Analysis

Descriptive statistics was conducted first to get an overview of the differences in latent variables between 2012 and 2016. These latent variables are the teacher level factors that are important for integration of ICT into education. Based on Table 4, the following observations can be made:

(1) In terms of the professional competency in educational use of ICT, there are 591 teachers in 2012 and 959 teachers in 2016 being compared. The professional competency in educational use of ICT is higher for teachers in 2016 (M = 3.22, SD = 0.514) than teachers in 2012 (M = 3.29, SD = 0.575).
(2) As for the collaboration for ICT integration, there are 602 teachers in 2012 and 980 teachers in 2016 being compared. The collaboration for ICT integration is higher for teachers in 2016 (M = 3.07, SD = 0.557) than teachers in 2012 (M = 2.88, SD = 0.692).
(3) For the progress towards student-centered education, there are 728 teachers in 2012 and 1112 teachers in 2016 being compared. The progress towards student-centered education is the same for teachers in 2016 (M = 3.32, SD = 0.539) than teachers in 2012 (M = 3.32, SD = 0.529).
(4) In terms of the perceived benefits on use of ICT, there are 684 teachers in 2012 and 1107 teachers in 2016 being compared. The perceived benefits on use of ICT is higher for teachers in 2016 (M = 3.41, SD = 0.525) than teachers in 2012 (M = 3.32, SD = 0.587).
(5) Concerning the autonomy to innovate, there are 536 teachers in 2012 and 908 teachers in 2016 being compared. The autonomy to innovate is higher for teachers in 2016 (M = 3.12, SD = 0.561) than teachers in 2012 (M = 2.96, SD = 0.630).
(6) As for recognition as a professional, there are 601 teachers in 2012 and 967 teachers in 2016 being compared. The recognition as a professional is higher for teachers in 2016 (M = 3.37, SD = 0.534) than teachers in 2012 (M = 3.19, SD = 0.585).
(7) In terms of the skills and practices in educational use of ICT, there are 516 teachers in 2012 and 1055 teachers in 2016 being compared. The skills and practices in educational use of ICT is higher for teachers in 2016 (M = 3.16, SD = 0.556) than teachers in 2012 (M = 3.05, SD = 0.579).

Table 4. Descriptive statistics for the factors on integration of ICT in education.

		N	Mean	Std. Deviation	Std. Error
Professional competency in educational use of ICT	2012	591	3.09	0.575	0.024
	2016	959	3.22	0.514	0.017
Collaboration for ICT integration	2012	602	2.88	0.692	0.028
	2016	980	3.07	0.557	0.018
Progress towards student-centered education	2012	728	3.32	0.529	0.020
	2016	1112	3.32	0.539	0.016

Table 4. *Cont.*

		N	Mean	Std. Deviation	Std. Error
Benefits on use of ICT	2012	684	3.32	0.587	0.022
	2016	1107	3.41	0.525	0.016
Autonomy to innovate	2012	536	2.96	0.630	0.027
	2016	908	3.12	0.561	0.019
Recognition as a professional	2012	601	3.19	0.585	0.023
	2016	967	3.37	0.534	0.017
Skills and practices in educational use of ICT	2012	516	3.05	0.579	0.026
	2016	1055	3.16	0.556	0.017

4.2. *t*-Test

Table 5 is a summary of hypotheses testing the result which shows the significant and non-significant differences in the teacher level factors that are important for the integration of ICT into education between 2012 and 2016. The detailed *t*-test result is included in Appendix B.

Table 5. Hypothesis testing result.

Alternative Hypothesis (H_1)	t	Significance	Result
Hypothesis 1: Teachers' perception on professional competency in educational use of ICT increased between 2012 and 2016	4.383	0.000	Retain the alternative hypothesis
Hypothesis 2: Teachers' perception on teachers' collaboration in use of ICT in education increased between 2012 and 2016	5.848	0.000	Retain the alternative hypothesis
Hypothesis 3: Teachers' perception on progress towards student-centered education increased between 2012 and 2016	.315	0.753	Reject the alternative hypothesis
Hypothesis 4: Teachers' perception of the benefits on use of ICT increased between 2012 and 2016	3.532	0.000	Retain the alternative hypothesis
Hypothesis 5: Teachers' perception on autonomy to innovate increased between 2012 and 2016	4.824	0.000	Retain the alternative hypothesis
Hypothesis 6: Teachers' perception of their recognition as a professional increased between 2012 and 2016	6.150	0.000	Retain the alternative hypothesis
Hypothesis 7: Teachers' perception on their skills and practices in educational use of ICT increased between 2012 and 2016	3.550	0.000	Retain the alternative hypothesis

The hypothesis testing result using *t*-test shown in Table 5 shows that that six statistically significantly mean differences exist, supporting the following six hypotheses:

(1) Professional competency in educational use of ICT: A statistically significantly mean difference 0.13 is found between teachers in 2012 and 2016, supporting hypothesis 1, as shown by *t*-test, t(1144.75) = 4.383, $p = 0.000$. Confidence interval of the difference (95%) is from 0.070 to 0.183.

(2) Collaboration for ICT integration: A statistically significantly mean difference 0.19 is found between teachers in 2012 and 2016, supporting hypothesis 2, as shown by *t*-test, t(1070.164) = 5.848, $p = 0.000$. Confidence interval of the difference (95%) is from 0.130 to 0.260.

(3) Benefits on use of ICT: A statistically significantly mean difference 0.09 is found between teachers in 2012 and 2016, supporting hypothesis 4, as shown by *t*-test, t(1789) = 3.532, $p = 0.000$. Confidence interval of the difference (95%) is from 0.042 to 0.147.

(4) Autonomy to innovate: A statistically significantly mean difference 0.15 is found between teachers in 2012 and 2016, supporting hypothesis 5, as shown by *t*-test, t(1442) = 4.824, $p = 0.000$. Confidence interval of the difference (95%) is from 0.091 to 0.217.

(5) Recognition as a professional: A statistically significantly mean difference 0.18 is found between teachers in 2012 and 2016, supporting hypothesis 6, as shown by *t*-test, t(1566) = 6.150, $p = 0.000$. Confidence interval of the difference (95%) is from 0.120 to 0.233.

(6) Skills and practices in educational use of ICT: A statistically significantly mean difference 0.11 is found between teachers in 2012 and 2016, supporting hypothesis 7, as shown by *t*-test, t(1569) = 3.550, $p = 0.000$. Confidence interval of the difference (95%) is from 0.048 to 0.167.

5. Discussion

The data analysis results demonstrated the increased perception on professional competency and attitudes of teachers who participated in the teacher training. This section discusses these factors in reference to the bodies of literature. It also interprets these findings in the context of teachers' professional development in Mongolia, through interviews with local primary school teachers and educational experts.

First, this study found out that teachers' professional competency in the educational use of ICT was improved through hands-on experiences in school-based trainings. This finding is in line with the argument that three principles of teacher training activities are important to improve teachers' professional competency: Activities are practice focused [35,36], teachers themselves are trainers [37], and sufficient time is allocated for training activities [38,39]. The participants of the training at a primary education level in Mongolia were self-learning different computer applications and software to develop their own training materials and classroom teaching materials. With these accumulated practical experiences over four years, teachers have become more productive and proactive, contributing to their professional competency.

Second, collaboration for ICT integration among teachers was promoted in the course of implementing teacher training activities. This finding agrees with the discussion on the importance of teacher collaboration in introducing new pedagogies and technologies into the educational activities [40–42]. The interviews with primary school teachers in Mongolia confirmed that teachers had built team work and long-term relationships among peers and between schools. This was reported to be effective in developing lesson plans to integrate ICT into their lessons, especially when ICT tools are considered as new and unfamiliar methodologies.

Third, teachers' perception of benefits on use of ICT has improved. This finding supports the belief of Cox [62] that teacher training should include activities that convey the value of using ICT in their educational practices. Further, this finding supplements the findings of Drent [9] and Buabeng-Andoh [46] that having a positive perception and awareness of the advantage of using ICT are significant factors affecting the use of ICT in educational activities. This result also supports the suggestion by Gudmundsdottir and Hatlevik [47] that teacher training activities should include practical sessions on the exemplary use of ICT. Specifically, participants of the teacher training activities in Mongolia learnt practical methods and relevant pedagogies with ICT use through developing localized teacher training materials. Teachers could directly incorporate new methodologies and examples into their daily lessons. As a result, teachers are more willing to use ICT in education as it was introduced as a tool for teachers to develop digitized training and teaching materials that were useful for themselves.

Fourth, teachers perceived higher autonomy to innovate after a series of teacher training activities. Previous studies emphasized the importance of collaborative leadership style in policy making, delegation of autonomy, open vision and willingness to take risks for introducing ICT into educational activities [49–51]. Interviews with local school leaders who facilitated the teacher training activities confirmed that school leaders themselves were aware of the advantage and thus encouraged teachers to be innovative in its use. Further, school leaders reported that the development of training and teaching materials using ICT has created the culture of sharing and collaborative learning further upgrading teachers' knowledge and skills. Therefore, school leaders' encouragement to innovate and the school environment to support peer learning had influenced positively the teachers' sense of autonomy to innovate.

Fifth, professional recognition from colleagues, school leaders, and the community have increased. Sheppard [48] noted that the successful implementation of ICT in schools requires the support from school management, teachers, and community members. Lee and Nie [51] pointed out that the timely recognition from school leaders could contribute to quality work and higher contribution to

schools from teachers. For school leaders in this study in Mongolia, they appreciated teachers being proactive in thinking about what teaching methodologies to be applied and how ICT can be utilized to make lessons more attractive to students. Interviews with student parents showed that they were aware of teachers using different types of teaching materials motivating their children in learning. Parents had positive evaluation of teachers for their effective teaching, since parents had observed that their children were more attracted and engaged in learning with digitized teaching materials. Teachers also reported in the interviews that the collaborations in developing high quality digital teacher training materials had positive influences on appreciating their colleagues.

Sixth, teachers' perception has increased on their basic ICT literacy. Previous research argued that teachers' acquisition of basic ICT literacy through training activities is considered as a prerequisite for teachers' educational use of ICT [44]. In 2012, Mongolian primary school teachers had just started to use ICT equipment and basic text editing and calculation programs. Tools and programs to visualize the lessons were also utilized by teachers but with limited functions. Fieldwork observations conducted in 2016 illustrated teachers' innovative use of ICT including creating teachers' platform to share and discuss each other's digital lesson materials. Further, teachers were videotaping their lessons to analyze for teaching improvement. They were also involved in video training material development, enabling them to acquire skills such as scenario development, video taking, and editing. It is evident that teachers' ICT literacy has evolved from basic ICT skills to enhance the quality of teaching in accommodating their specific needs with available resources.

Seventh, regarding teachers' perception on progress towards student-centered education, this study did not identify significant changes between 2012 and 2016. The study conducted in the United States on science teachers' technological pedagogical knowledge found that the use of technology to support the development of higher-level skills of students was limited although teachers used ICT for lesson preparation [63]. Reflecting the Mongolian context, the finding can be interpreted as follows: Teachers' perception on progress towards student-centered education was already high in 2012. This finding could be explained partially by policy implementations in Mongolia. The New Education Standard introduced in 2003 encouraged the shift from teacher-centered education to student-centered education [22]. At the same time, "ICT Vision-2010 in Education Sector" approved by the Ministry of Education, Culture, Science and Sports (MECSS) promoted the use of ICT for students' knowledge development on all educational levels. These policies emphasized student-centered learning methodologies using ICT. Therefore, teachers were already aware of the needs and requirements to use ICT to promote student-centered education in 2012 when the baseline survey took place. In fact, survey data indicated that teachers' perception of progress towards student-centered education marked one of the highest mean score in the baseline survey. The score remained high in the impact survey of 2016, indicating that this was an important perception of teachers.

6. Conclusions

Promoting professional development of teachers to achieve quality education has become more relevant than ever worldwide, as emphasized in the Sustainable Development Goal 4. Teachers' professional development is especially important in the context of educational change, such as the introduction of ICT into education. In Mongolia, professional development for primary school teachers is considered a key domain to achieve quality education. With the assistance from international communities, a series of professional development projects have been implemented in Mongolia.

This study aimed to understand how teacher training programs focusing on ICT use in educational practices had influence on teacher level factors that are important for ICT integration in educational activities. The study employed the baseline survey data of 2012 and impact survey data of 2016 collected from teacher training participants. Factor analysis identified seven important factors to illustrate the effectiveness of teachers' professional development program on educational use of ICT. Data analysis found that professional development activities for primary school teachers in

Mongolia had positive influences on six teacher level factors. These are professional competency in educational use of ICT, collaboration for ICT integration, benefits on use of ICT, autonomy to innovate, recognition as a professional, and skills and practices in educational use of ICT. Qualitative data collected from interviews and fieldwork observations were used to interpret the results. This comparative analysis using data spanning over four years have proven the visible impact of professional development activities on teachers' perception. These findings contribute to the discussion on teachers as the change agent as part of the educational change and the implications of effective teacher professional development activities. It is recommended that future professional development activities on educational use of ICT should focus on the long-term involvement of teachers on the grassroots level and convey the benefits of the use of ICT. At the same time, training activities should promote teacher collaboration through hands-on experiences in creating digital teacher training and classroom teaching materials. These activities may effectively promote teachers' integration of ICT in their educational activities.

Further, as the study focused on primary school teachers in Mongolia, it is recommended that subsequent studies extend the scope of research onto secondary school teachers to further understand the influence of professional development activities in the basic education sector.

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Appendix A Rotated Component Matrix of Factor Analysis

Rotated Component Matrix [a]								
	Component							
	1	2	3	4	5	6	7	8
I feel professionally competent as teacher because I can develop and use digital contents in my teaching	0.782	0.173	0.149	0.108	0.049	0.071	0.187	0.180
I feel professionally competent as teacher because I can operate ICT equipment in my teaching	0.758	0.107	0.172	0.101	0.062	0.010	0.189	0.228
I am satisfied with my job as teacher because I can develop and use digital contents in my teaching	0.743	0.087	0.100	0.151	0.087	0.146	0.155	0.005
I feel professionally competent as teacher because I develop and use digital teacher training materials	0.740	0.163	0.168	0.052	0.000	0.099	0.200	0.164
I am satisfied with my job as teacher because I can operate ICT equipment in my teaching	0.726	0.113	0.109	0.139	0.130	0.110	0.195	0.050
I am satisfied with my job as teacher because I develop and use digital teacher training materials	0.690	0.142	0.134	0.124	0.071	0.145	0.100	−0.077
I am satisfied with my job as teacher because I can use Scratch in my teaching	0.646	0.234	0.035	0.053	0.146	0.033	0.122	−0.276
I feel professionally competent as teacher because I have professional development opportunities	0.604	0.173	0.264	0.076	0.190	0.243	0.011	0.031
I feel professionally competent as teacher because I can use Scratch in my teaching	0.527	0.280	0.141	0.020	0.123	−0.034	0.181	−0.265
I am satisfied with my job as teacher because I have professional development opportunities	0.508	0.151	0.208	0.099	0.260	0.313	−0.072	−0.218
I am satisfied with my job as teacher because I have support from school in my teaching	0.463	0.234	0.154	0.089	0.400	0.446	−0.045	−0.135
I feel professionally competent as teacher because I have support from school in my teaching	0.424	0.219	0.308	0.078	0.412	0.247	0.026	−0.113
We work in a systematic way to develop teaching based on ICT	0.237	0.773	0.033	0.098	0.098	0.103	0.116	−0.049
There is a systematic sharing of pedagogical experience in use of ICT	0.229	0.745	0.078	0.103	0.117	0.132	0.124	0.043

Rotated Component Matrix [a]								
	Component							
	1	2	3	4	5	6	7	8
There are clear pedagogical goals for the schools ICT initiative	0.221	0.734	0.080	0.093	0.212	0.101	0.078	0.070
School management supports us in understanding how the use of ICT can improve teaching	0.078	0.685	0.173	0.111	0.282	0.138	0.151	−0.123
I can use subject-specific digital teaching aids in my teaching	0.158	0.617	0.150	0.062	0.043	−0.070	0.161	−0.139
Teachers are organized so that we cooperate well	0.134	0.565	0.178	0.190	0.242	0.184	0.016	0.400
I am allowed to use ICT to improve my teaching	0.138	0.508	0.291	0.327	0.045	0.051	0.066	0.127
We share our experiences across different units/sectors	0.147	0.486	0.172	0.224	0.256	0.200	0.064	0.437
Teachers are willing to try new methods in classroom teaching	0.167	0.481	0.172	0.229	0.294	0.169	0.053	0.373
I think the support from school makes a progress towards student-centered education	0.172	0.143	0.791	0.140	0.182	0.101	0.127	0.095
I think the use digital contents makes a progress towards student-centered education	0.233	0.144	0.781	0.165	0.070	0.062	0.186	0.007
I think the use of ICT tool makes a progress towards student-centered education	0.239	0.116	0.769	0.167	0.080	0.033	0.171	0.053
I think professional development opportunities make a progress towards student-centered education	0.219	0.140	0.713	0.126	0.097	0.125	0.170	−0.051
I use ICT to make students more interested in different subjects and lesson contents	0.150	0.124	0.150	0.834	0.158	−0.005	0.108	0.078
By using ICT it is easier to motivate students	0.152	0.129	0.235	0.826	0.100	−0.022	0.085	0.081
I feel that ICT contributes to make my teaching more varieties	0.135	0.174	0.141	0.806	0.110	0.068	0.120	0.056
By using ICT it is easy to differentiate the teaching I give to different students	0.123	0.273	0.035	0.554	0.013	0.172	0.068	−0.353
Teachers have an opportunity to make decisions that are relevant for their own teaching	0.134	0.281	0.109	0.122	0.748	0.072	0.196	−0.009
School management believes I am a good teacher	0.191	0.152	0.107	0.068	0.732	0.102	0.125	0.080
School management encourages me to try new ideas for teaching methodology	0.114	0.382	0.135	0.225	0.622	0.125	0.120	0.128
Do you think that your work as teacher is appreciated by the following constituents - Colleagues	0.148	0.141	0.104	0.022	0.077	0.814	0.089	0.110
Do you think that your work as teacher is appreciated by the following constituents - Parents & Community	0.150	0.058	0.024	0.066	0.021	0.788	0.162	0.094
Do you think that your work as teacher is appreciated by the following constituents - School management	0.187	0.148	0.130	0.012	0.336	0.703	0.037	−0.143
I think my skills for developing digital contents have improved	0.394	0.172	0.191	0.111	0.061	0.039	0.669	0.088
I think the teachers in my school have ICT skills	0.353	0.206	0.204	0.115	0.137	0.111	0.653	0.045
I think the use of blended teaching is spreading	0.269	0.228	0.203	0.092	0.219	0.167	0.637	−0.069
I think digital teacher training materials are appropriate for professional development of teachers	0.207	0.147	0.342	0.225	0.143	0.128	0.585	−0.062
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.								
[a] Rotation converged in 8 iterations.								

Appendix B Independent Samples *t*-Test Result

Independent Samples Test										
		Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
		F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Professional competency in educational use of ICT	Equal variances assumed	6.197	0.013	4.499	1548	0.000	0.13	0.028	0.071	0.182
	Equal variances not assumed			4.383	1144.75	0.000	0.13	0.029	0.070	0.183
Collaboration for ICT integration	Equal variances assumed	25.521	0.000	6.156	1580	0.000	0.19	0.031	0.133	0.257
	Equal variances not assumed			5.848	1070.16	0.000	0.19	0.033	0.130	0.260
Support and ICT tools to achieve student-centered education	Equal variances assumed	0.542	0.462	0.315	1838	0.753	0.01	0.026	−0.042	0.058
	Equal variances not assumed			0.317	1574.23	0.752	0.01	0.025	−0.042	0.058

Independent Samples Test										
		Levene's Test for Equality of Variances		*t*-Test for Equality of Means						
		F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Benefits on use of ICT	Equal variances assumed	0.512	0.474	3.532	1789	0.000	0.09	0.027	0.042	0.147
	Equal variances not assumed			3.440	1325.14	0.001	0.09	0.027	0.041	0.148
Autonomy to innovate	Equal variances assumed	2.548	0.111	4.824	1442	0.000	0.15	0.032	0.092	0.217
	Equal variances not assumed			4.682	1020.60	0.000	0.15	0.033	0.090	0.219
Job appreciation	Equal variances assumed	0.949	0.330	6.150	1566	0.000	0.18	0.029	0.120	0.233
	Equal variances not assumed			6.021	1185.09	0.000	0.18	0.029	0.119	0.235
Skills and practices in education use of ICT	Equal variances assumed	0.010	0.921	3.550	1569	0.000	0.11	0.030	0.048	0.167
	Equal variances not assumed			3.500	985.44	0.000	0.11	0.031	0.047	0.168

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