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EduXs: multilayer educational services platforms

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Abstract

How to use the online social learning communities to improve quality and quantity of interactions in physical social learning communities is an important issue. This work describes the design and implementation of multilayer educational services platforms that enable learners to establish their own online social learning communities and integrate their online social learning communities into a large public social learning portal site—EduCities. Multilayer educational services platforms were designed to integrate various individual online social learning communities, and to map these communities into physical social learning communities. This work proposes and implements an architecture called EduXs, and integrates it with K-12 social learning communities. One year after the EduXs system was released on the Internet, 1,849 schools, 15,772 classes, and 130,908 individuals in Taiwan had registered to use the system to construct their own online social learning communities. Among these registered users, 18.8% of registered schools, and 24.7% of registered classes continue to use the system. Evaluation results indicate that the system is accepted by teachers and students.

Keywords: Learning communities; Architectures for educational technology system; Distributed learning environments; Elementary education; Improving classroom teaching

1. Introduction

Physical social learning communities, such as schools, classes, families, and working places, tend to be long lasting. Members of such physical social learning communities generally share the same value systems and visions, and frequently interact with other like-minded individuals. Learners, particularly K-12 learners, spend most of their time in physical social learning com-

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munities, namely schools, classes, and families. Consequently, physical social learning communities cannot be neglected in the formation of online social learning communities, particularly for K-12 learners.

Because of the development of information technology, online social communities spread rapidly (Oren, Nachmias, Mioduser, & Lahav, 2000; Preece, 2000; Rheingold, 1993; Schuler, 1996; Wachter, Gupta, & Quaddus, 2000). Most virtual social learning communities are designed for Internet users. However, K-12 learners require platforms to interact with their parents, teachers, and classmates on the Internet, rather than interacting with random web surfers. The evolution of online social learning communities in K-12 will be strongly influence by the physical social learning communities. Such processes are likely to blur the boundary between physical and online social communities (Lazar, Tsao, & Preece, 1999).

Technologies for building online social learning communities are likely to be helpful in enhancing the quality and quantity of interactions among physical social learning communities. However, like other social groups, physical social learning communities, such as K-12 social learning communities, involve their unique organizations (Owens, 1998). Social organizations involved in K-12 social learning communities, including the Ministry of Education, Bureau of Education, schools, classes, learning clubs, homes, individual learners, and so on. The formation of online social learning communities in K-12 thus cannot neglect these physical social organizations. Social learning communities abound in the physical social learning environment, and even online.

A Website named ''EduCities'' was constructed to provide an architecture allowing K-12 learners to interact with others (Chan, Hue, Chou, & Tzeng, 2001). The EduCities Website is a popular educational portal in Taiwan, and supports the establishment of online social learning communities. The main users of EduCities are teachers, students, and parents. Notably, numerous new learning models are in practice on the Website (Chang, Yang, Yu, & Chan, submitted for publication). However, although EduCities successfully organize online social learning communities (Young, Chan, & Lin, 2002), users continue to present numerous user requirements. One requirement is that teachers and students still spend most of their time in schools and families. Consequently, teachers and students are focused primarily on these environments, which they encounter daily, and where they have a sense of identity and belonging. Naturally, system designers cannot require that users conduct all of their learning activities via EduCities while neglecting their physical social learning environment. Rather, learning portal sites such as EduCities must be reorganized to suit school- and class-based learning styles, particularly in K-12 learning environments. Overall, physical social learning environments have a distinct organization and ecology, and educational portals must be designed accordingly. The EduCities Website thus is being modified to meet the expectations of users. Numerous EduTowns have been created under the EduCities Website, each corresponding to an individual school. Moreover, within each the EduTown, numerous EduVillages have been created to correspond to individual classes. Finally, within each EduVillage, numerous EduCitizens have been created, each corresponding to an individual learner. This type of multilayer educational services platforms design was created based on the request of the majority of users, and the results demonstrate that this design is helpful in boosting interactions among users.

This work attempts to develop a multilayer educational services platforms architecture via which learners can construct their own online social learning communities, integrate these learning communities with other such communities and interact with others on different platforms.

These multilayer educational services platforms are mapped onto physical social learning environments based on user expectations. The architecture, called EduXs, is described, implemented, and integrated with the K-12 learning environment to establish multilayer educational services platforms. Sections 2 and 3 then describe the concept and implementation of the EduXs system, respectively. Finally, Section 4 evaluates the system to verify its design and establish its practical usefulness, as presented in Section 4.

2. The EduXs concept

An educational portal site provides various services to learners. Online social groups are much like other social groups in having their own unique types of organization, and educational portal sites should consider these types of organization. EduXs attempts to extend physical social learning environments into online multilayer educational services platforms that allow participants to easily establish and organize online learning communities for interacting with others. Since many existing educational portal sites are constructed using a flat design, online communities are generally built on this conceptual flat platform. However, the physical world of learning contains, numerous hierarchical social organizations, such as the Ministry of Education, Bureau of Education, schools, classes, learning clubs, homes, and so on. Accordingly, EduXs reorganizes educational portal sites into several multilayer platforms which suitable for various educational social organizations. Fig. 1 compares the educational portal site and EduXs concepts.

2.1. EduCities

As described earlier, EduCities is an educational portal site. All activities at the EduCities website occur in the conceptual central space, which is the entry point to all of the various systems developed by different researchers (Chan et al., 2001). EduCities provides various learning resources. A learner can find not only learning activities in which to participate and learning materials to read, but also learning companies, tutors and tutees if s/he wishes to contribute her/his learning experience. Thus far, the EduCities Website has been successful in organizing online learning communities. One year after the establishment of EduCities, users have provided extensive feedback. Particularly valuable has been the feedback indicating that users enjoy many social relationships through physical social learning environments, and expect online social learning communities to provide similar physical social learning environments. Accordingly, system designers cannot entirely neglect physical social relationships when designing online social communities. Participants in physical social communities have their own identities, and expect these identities to extend from physical to online communities. Moreover, since social communities have multilayered architectures, the EduCities platform must be reorganized into a multi-platform to facilitate user participation in learning activities. The rights, interactions, and relationships involved in physical social learning communities can be realized online. Members of both online and physical social communities have share common views, values, and visions. Notably, online social communities can support physical groups by increasing the quantity and quality of interactions. Consequently, the EduCities Website was re-organized in response to user requests. Under the modified EduCities structure, many schools are constructing their own "miniature

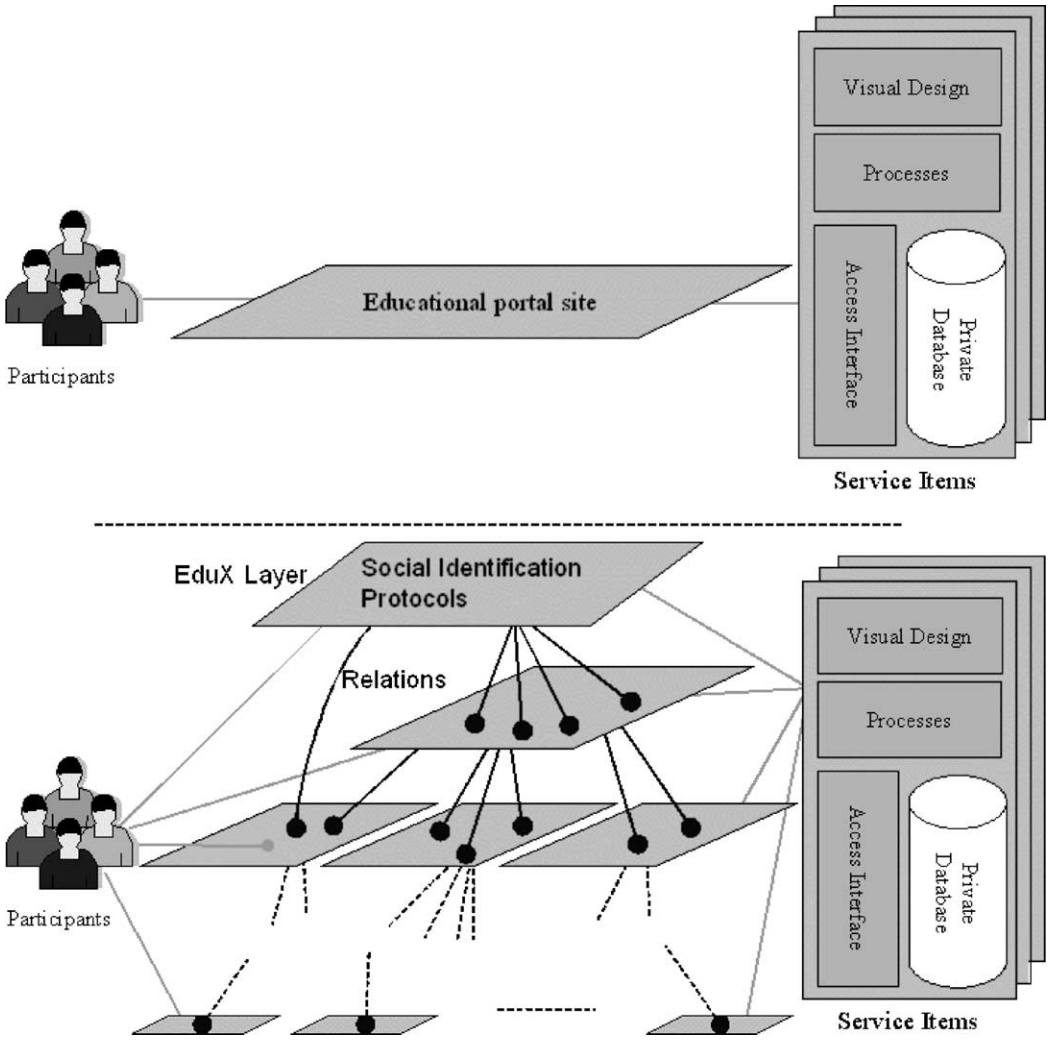

Fig. 1. Educational portal sites vs. EduXs concept.

versions of the EduCities'', called EduTowns. An EduTown is a school-based learning environment. All inter-school activities occur in EduCities, while intra-school activities occur in a particular EduTown. Each EduTown is managed by a mayor, typically a teacher with a computer science background. Furthermore, each EduTown contains numerous EduVillages, which are class-based learning environments representing individual classes. Each EduVillage is also managed by a mayor, usually a teacher or a student with a computer science background. Each EduVillage contains many EduCitizens, each of which represents a personal learning environment. Each EduCitizen is managed by a teacher, or by a student. Following the introduction of this multilayer concept, the real ''physical social learning communities'' are established in online EduCities.

2.2. Definition of EduXs

The concept of EduXs is used here to describe the re-organized multilayer educational services platforms. Fig. 2 shows the definition of the EduXs, which comprise the EduX layers and EduX relations. The EduXs provides a multilayered structure enabling learners to construct online social learning environments. Online participants interact via different EduX layers. Each EduX layer contains many service items developed by third-party developers and provided to participants to assist them in constructing their own online social learning environments.

2.2.1. EduX layers

An EduX layer comprises social identification, services, protocols, and participants. Each EduX layer is managed by at least one participant.

2.2.1.1. Social identification. EduX layers are named using a set of social identifications. For example, a set of social identifications can be defined as inter-school, school, class, or individual by the system developers. Participants in the EduXs can determine their own status based on these social identifications.

2.2.1.2. Service items. Services in EduX layers include content services, community services, application services, and other services. These services are provided by third-party developers. Different services are plugged into different EduX layers at the discretion of the system operators.

EduXs = (EduX layers, EduX relations)

EduX layer = (Social identification, Services, Protocols, Participants)

Social identification $\in \{ SID_1, SID_2, \ldots \ldots, SID_m \}$

The name of $SID_1, SID_2, \ldots, SID_m$ **are defined by system developers**

Services $= \sum$ **Service items**

Service item = (Software applications, Content)

Protocols: interactive mechanizes among service items, EduX layers, and participants

Participant = (Participant identification, Participant relations)

Participant identification $= \{ PID_1, PID_2, \ldots \ldots, PID_m \}$

The name of $PI_1, PI_2, \ldots, PI_m$ **are defined by system developers**

Participant relations $= (PR^v, PR^h)$

PR^v**: vertical relations of participant,** $R^v \geq 0$

PR^h**: horizontal relations of participant,** $R^h \geq 0$

EduX relation $= (R^v, R^h)$

R^v**: vertical relations of EduX layers,** $R^v \geq 0$

R^h**: horizontal relations of EduX layers,** $R^h \geq 0$

Fig. 2. Definition of EduXs.

Notably, the mayor of a given EduX can decide which service items can be accessed via their EduX, and to whom.

2.2.1.3. Protocols. Activities protocols are the mechanisms of interaction among service items, EduX layers, and participants.

2.2.1.4. Participants. Different participants have different roles in the EduXs model. These roles are specified by the identity and relationships of the participant. For example, the identity sets of participants can include president, member of staff, teacher, student, parent, volunteer, or computer agent (Chan & Chou, 1997).

2.2.2. Relations

EduXs involves two basic vector relationships, the vertical relationship $\mathbf{R}^v$, and the horizontal relationship $\mathbf{R}^h$. $\mathbf{R}^v$ denotes the vertical relationship between two EduX layers, while $\mathbf{R}^h$ represents the horizontal relationship between two EduXs from the same layer. The two basic vectors can support thousands of combinations. Fig. 3 displays four basic relationships between EduXs, as follows:

1. Isolated relation: the isolated relationship is the basic relationship in EduXs. In an isolated relationship, the number of $\mathbf{R}^v$ and $\mathbf{R}^h$ equals zero.
2. One-level relations: three basic different types of one-level relations exist.
3. Two-level relations: two-level relations are almost always evaluated on the basis of one-level relations.
4. Three-level relations: three-level relations are assessed from one- and two-level relations.

Relationships beyond three-level relationships can be formed through combinations of isolated relationship, one-level relationships, two-level relationships, and three-level relationships.

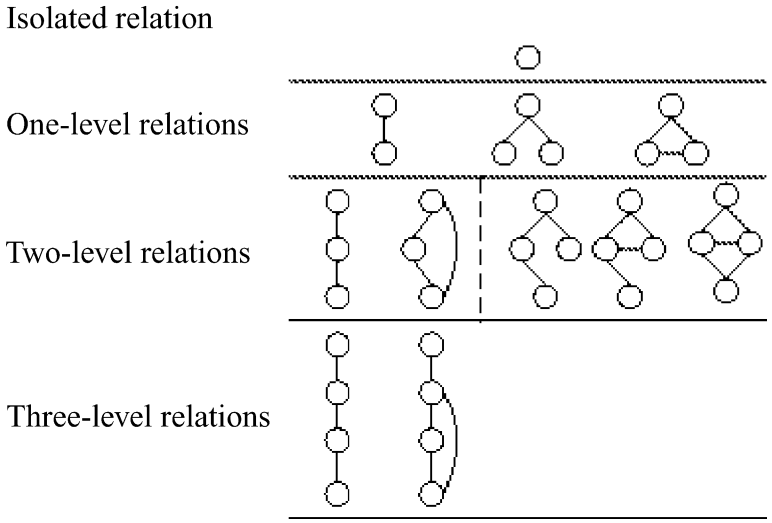

Fig. 3. Some types of EduXs relations.

2.3. SDA circle on EduXs

The EduXs are multilayer educational services platforms. Researchers can release their systems to participants via these platforms. The supply–delivery–analysis (SDA) circle represents the relationship between system developers and participants of EduXs, and is shown in Fig. 4.

2.3.1. Supply

In EduXs, system suppliers provide service items to participants. Suppliers can include researchers, teachers, software companies, educational volunteers, and so on. These service items are plugged into suitable EduX layers via a service items management interface, which is managed by those maintaining the EduXs system.

2.3.2. Delivery

Service items, which plug into the EduXs service items management interface, are delivered to participants via the hierarchical EduX layers.

2.3.3. Analysis

Participants using the service items produce numerous activity logs. The technologies applied to analyze such data depend on analyst requests. The data analysis involves several steps, including data collection, cleaning, selection, transformation, mining, and so on (Han & Kamber, 2001). The analyzed data serve as feedback for system developers wishing to modify their systems.

2.4. Architecture of the EduXs system

Fig. 5 shows the EduXs system architecture. The EduXs system comprises several different components, including management of the relations among layers, layer simulation, management of the relations among participants, statistical analysis, service items management, databases, and so on. These components are described as follows:

- Management of the relations among layers: this component manages the relationships among all of the layers, and controls data feedback to the layer simulation component.

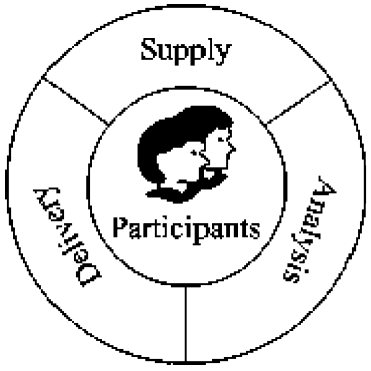

Fig. 4. SDA circle.

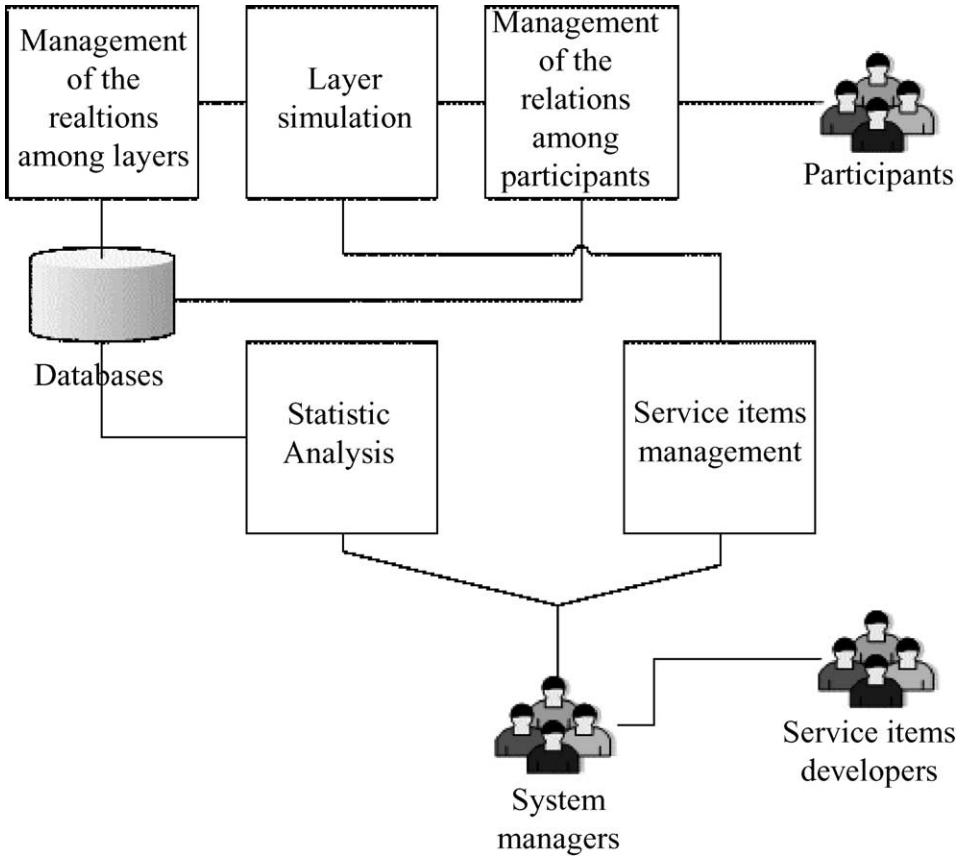

Fig. 5. System architecture of EduXs system.

- Layer simulation: the data sent from the management of the relations among layers component is represented to users via a layer simulation component.
- Management of the relations among participants: this component manages relationships among participants.
- Statistical analysis: all participant data is gathered into databases. The statistical analysis component controls data analysis, and presents the analytical results to the system managers. System managers then forward this analyzed data to the service item developers.
- Service items management: this component manages all service items. This component also dispatches service items to suitable EduX layers based on user requests.
- Databases: databases store all of the system data and log data.

3. Implementation

The EduXs system is implemented to study the EduXs concept. Social identifications of cities, towns, villages, and citizens are used to help participants understand the concept of different layers.

3.1. EduX layers of the EduXs system

3.1.1. Social identification

The EduXs system includes four EduX layers, known as EduCity, EduTown, EduVillage, and EduCitizen. Fig. 6 illustrates the relations among the EduX layers, environments, and activity types. Their features are described as follows:

1. EduCity: an EduCity is learning portal site. Inter-school activities occur on this layer.
2. EduTown: an EduTown represents a school-based learning environment under the EduCity. Intra-school and inter-class activities occur on this layer. An EduTown is managed by a mayor typically a teacher with a good understanding of computers.
3. EduVillage: an EduVillage represents a class-based learning environment under an EduTown. Intra-class activities occur in an EduVillage. Each EduVillage is managed by a mayor, who is either a teacher or a student.
4. EduCitizen: an EduCitizen represents an individual-based learning environment under an EduVillage. All personal learning environments are built in this layer. EduCitizens are managed by the learners they represent.

3.1.2. Services

From the definition of the EduXs in Section 2.2, services are combined with numerous service items. Different EduX layers require different services. Services provided in the EduXs system are categorized into three types—service items for schools (SIFSs), which suit school-based learning environments, service items for classes (SIFCs), which suit class-based learning environments, and service items for participants (SIFPs), which suit individual-based learning environments. The service items in each EduX layer are further divided into content services, community services, application services, and other services. Table 1 lists all of the service items now provided via the EduXs system.

3.1.3. Participants

As Fig. 2 displays, the definition of participants includes participant identification and participant relations. In the EduXs system, participants play one of four different roles, as follows:

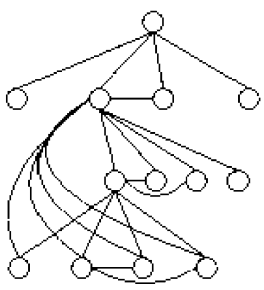

Fig. 6. Relationships among EduX layers, environments, and activity types.

Table 1
Classification of service items

Services for layers	Types of services			
	Content services	Community services	Application services	Other services
SIFSs (Service items for schools)	Material upload system, school-based educational news, FAQ boards, etc.	Bulletin boards, chat rooms, discussion boards, voting system, etc.	School calendar records, school notice boards, school timetables, free web spaces, online courses system, etc.	School homepage, e-cards, etc.
SIFCs (Service items for classes)	Class albums, English typing practicing system, K-12 computer teaching materials, etc.	Bulletin boards, chat rooms, discussion boards, voting system, life experience sharing board, etc.	Class notice boards, announcements, class calendars, etc.	Class homepage, e-cards, etc.
SIFPs (Service items for participants)	Daily records, personal filing system, personal notes, etc.	Personal chat room, web mail, personal address book, etc.	Mailbox, announcements, notes, personal games, etc.	Individual homepage etc.

P1 = (Mayor of the EduCity, managing all mayors of EduTowns)
P2 = (Mayor of an EduTown, managing all mayors of EduVillages in the EduTown)
P3 = (Mayor of an EduVillage, managing all participants in the EduVillage)
P4 = (Participant, manages their individual learning environment)

3.2. Relations of the EduXs system

As Fig. 6 shows, inter-school activities occur in the EduCity layer, intra-school and inter-class activities occur in the EduTown layer, intra-class and inter-participant activities occur in the EduVillage layer, and individual activities occur in the EduCitizen layer.

3.3. SDA circle of the EduXs system

The SDA circle, implemented in the EduXs system, is described later:

Supply
All service items, including SIFSs, SIFCs, and SIFPs occur in different EduX layers. Service items are further classified into four types, including content service items, community service items, application service items, and others, as designated by the suppliers of the items.
Delivery
The EduXs system maintains channels connecting all schools, classes, and individual learners using the EduXs system.
Analysis
Three pieces of basic system data are automatically collected namely Web logs, activity logs, and questionnaire logs. More data can be logged if necessary. The results of the data analysis provide feedback to system developers. Section 4 discuss some examples on this.

3.4. System deployment

The EduXs system is developed and deployed on the Internet. System deployment involves five parties: client side, load balance devices, Web servers, application servers and databases, as follows:

1. Client side: the user uses a browser to browse the EduXs system.
2. Load balance devices: the load balance devices deal with the huge volume of data being accessed simultaneously by numerous participants. Many commercial products are used, such as a layer 4 switch and a cache flow.
3. Web servers: web servers handle all user requests. Moreover, application servers are called by web servers when required.
4. Application servers: application servers store all the application processes, which are called by the web servers as required. Application processes access the databases as necessary.
5. Databases: databases store all system data, data on user activities and log data.

4. System evaluation

The EduXs system was released on the Internet on 5 January, 2001 (http://edutowns.educities.edu.tw/). The Website is written in Chinese (traditional characters) because the main system users are elementary, junior and senior high school students and teachers in Taiwan. Under the EduCity educational portal Website, teachers and students can apply for their school to be represented as an EduTown, and can then establish their own EduVillages and EduCitizens within that EduTown. Teachers and students can use the system either in school or at home. To evaluate the system performance, analysis of EduX layers usage, system total page-views, and online questionnaires are conducted.

4.1. Analysis of EduX layers usage

Taiwan has a total of 4,086 schools. Among these, 2,621 are elementary schools, 763 are junior high schools, 493 are senior high schools, and 209 are universities. All of these schools can apply to use the EduXs system. Although many schools applied to use the EduXs system after the system was released on the Internet, some did not remain active users following their registration. Consequently, to accurately analyze the usage rate among Taiwanese schools, a formula was created to distinguish the active and inactive EduX layers.

4.1.1. Method

All application data were collected daily, from September 2001 to May 2002. Moreover, page-view data from each EduX layer was also collected. The following formula was used to distinguish the active and inactive EduX layers.

$$\text{Active\_Rank} = \log_2\left(\frac{\Delta\text{Page}-\text{views}}{\#\text{Periods} \quad * \quad \#\text{Members}}\right)$$

ΔPage-views; accumulated page-views of the EduX layer on the sample days; #Periods; sample days; #Members; members of the EduX layer.

From the earlier definition, if the Active_Rank exceeds −2, then the EduX layer is active. Active thus means that members visit their EduX layer at least once a week. If the Active_Rank is below −2, then the EduX layer is inactive. Inactive thus means that members visit their EduX layer less than once a week.

4.1.2. Results

According to the system database statistics from the sample days, over 1849 EduTowns, 15,772 EduVillages, and 130,908 EduCitizens have registered to use the EduXs system. Fig. 7 displays the growth of the EduXs system.

Fig. 8 displays the distribution of registration among different types of schools. As Fig. 8 presents, 38% of elementary schools, 54% of junior high schools, 62% of senior high schools, and 70% of universities have registered to use the system to develop online social learning communities. From the formula defined in Section 4.1.1, among the registered schools, 24% of elementary schools, 15% of junior high schools, 13% of senior high schools,

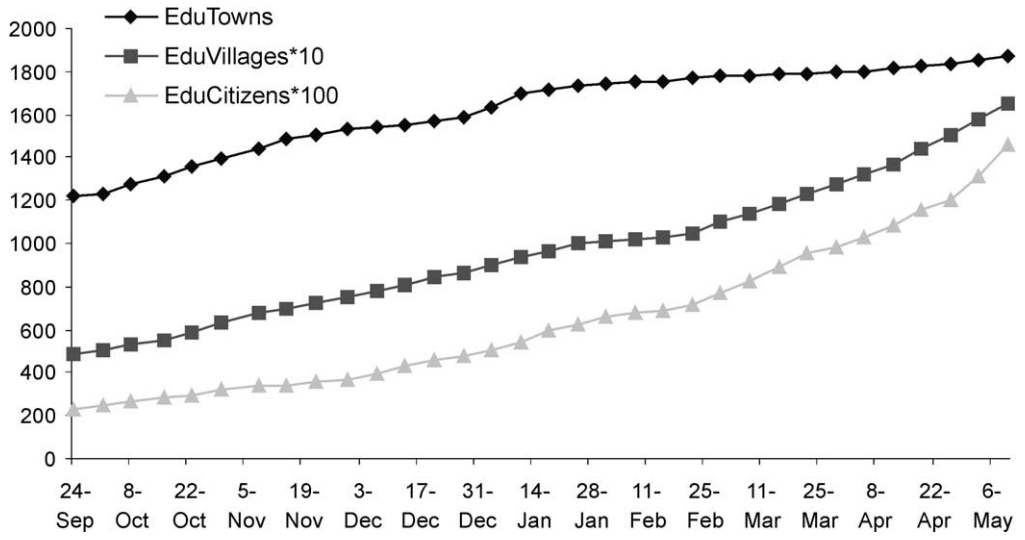

Fig. 7. Growth of EduXs system.

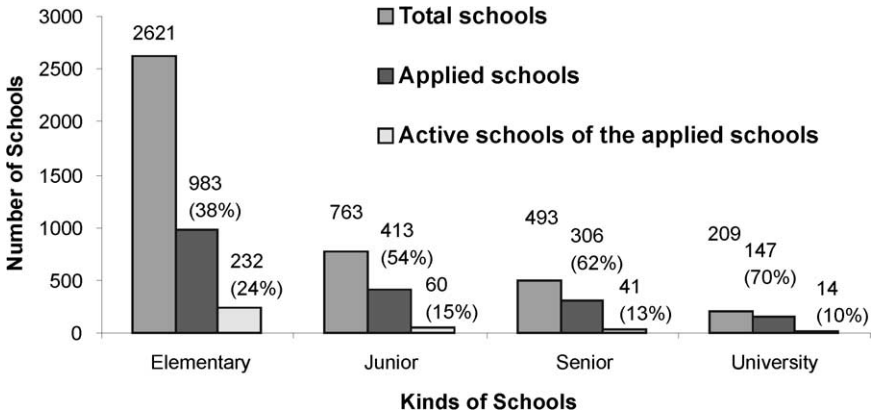

Fig. 8. Number of schools registered to use EduXs system.

and 10% of universities actively use the system. A total of 45% of Taiwanese schools thus have applied to use the system, and 18.8% (347 schools) among the registered schools are active users.

The formula for calculating active EduX layer was also applied to EduVillages. As shown in Fig. 9, 10,422 elementary school classes, 3,815 junior high school classes, 1,187 senior high school classes, and 348 university classes applied to use the system. Among the classes that applied, 27% of elementary school classes, 20% of junior high school classes, 21% of senior high school classes, and 12% of university classes were active system users according to the definition of the formula in Section 4.1.1 after registering to use the system. A total of 15,772 classes in Taiwan applied to use the system, among whom 3,889 (25%) classes were active.

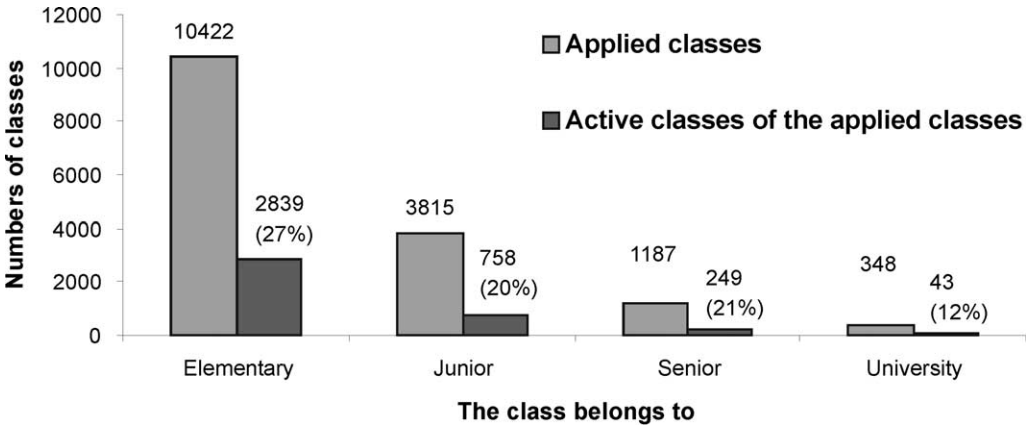

Fig. 9. Number of classes registered to use EduXs system.

4.1.3. Discussion

From Fig. 7, the growth in registrations from schools, classes, and individuals reflects the fact that the multilayer educational services platforms are accepted by schools, classes, and individuals.

Fig. 8 reveals that the elementary schools have the highest retention rate (24%), followed by junior high schools (15%), senior high schools (13%), and finally universities (10%). This situation also occurred in classes as shown in Fig. 9. One possible reason for the high retention rate in elementary school classes is that elementary students lack knowledge of information technologies and require a support system to help them to establish their online social communities. But further evaluation is required in this issue.

4.2. Analysis of the system total page-views

Online data logs and their analyses can be used directly to elucidate the system status. As described earlier, approximately 347 schools and 3,889 classes in Taiwan regularly use the system. Naturally, numerous log entries exist for all of these members. Using these logs, system total page-views were analyzed, and the user behavior behind the statistics was discussed.

4.2.1. Method

All system page-views logs were collected in a database. Simple statistical software was then applied to analyze the data. Total page-views were gathered daily over a two-week period, from 8 April to 21 April 2002.

4.2.2. Results

Fig. 10 shows statistics on system total page-views. The horizontal axis represents time, with the scale expressed in units of 2 hours.

4.2.3. Discussion

Fig. 10 displays three major daily peaks from Monday to Friday. The first peak is from 8 a.m. to 12 p.m., the second peak is from 1 p.m. to 4 p.m., and the third peak is from 5 p.m. to 11 p.m.

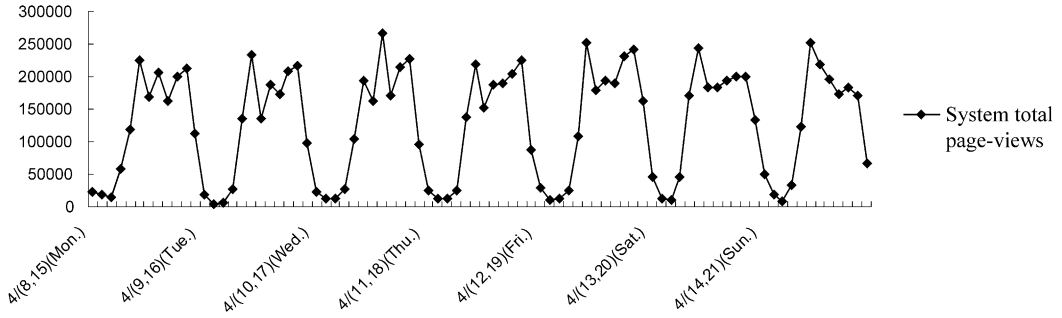

Fig. 10. Statistics of system total page-views.

The first two peaks indicate that students are using the system at school, while the third peak indicates that students are also using the system at home. Data gathered on the weekends shows that students were also using the system then. The system is heavily patronized both in and out of school, and on weekends as well as weekdays. Overall, the data shows that system usage is relatively continuous.

4.3. Online questionnaires

Online questionnaires are frequently used to collect basic user data and responses. Such questionnaires also represent an easy method of gathering the views of a large number of people. Accordingly, this study administered two simple online questionnaires to teachers and students using the EduXs system.

4.3.1. Method

The questionnaires were displayed on the website during a two weeks period from 8 April to 21 April 2002. All user responses were stored in the system database. The validity of the data was ensured by requiring that users who connected to the system answered the questionnaire no more than once.

4.3.2. Results

Tables 2 and 3 show the results obtained from the two questionnaires filled in by teachers and students, respectively. One-hundred-and-seventy-nine copies were collected from teachers, and 5595 were gathered from students. Some teachers and students rejected or ignored some questionnaire items, meaning the total number of valid responses in less than the total number of questionnaires returned.

4.3.3. Discussion

From Table 2, most teachers agree that the EduXs system and the multilayer educational services platforms design are useful. The responses to questionnaire items 4 to 6, presented in Table 2, indicate little difference in the preferences of teachers for interacting with their students in school-based, class-based, or individual learning environments. This situation also occurs in the questionnaire completed by students. These results support our assumption that teachers and students require different platforms to interact with each other depending on differences in their expectations. The initial data from Tables 2 and 3 shows that teachers and students agree that the EduXs system is helpful in supporting the construction of online social learning communities.

Table 2
Results of the questionnaire given to the teachers [responses; % (*n*)]

	1	2	3	4	5
1. EduXs system facilitates interactions with my students	34 (60)	48 (86)	11 (19)	3 (5)	4 (7)
2. EduXs helps reduce my teaching load	31 (56)	34 (61)	25 (44)	6 (10)	4 (7)
3. I can easily establish an online social learning environment using the system design	21 (37)	37 (66)	29 (53)	9 (16)	4 (7)
4. I prefer to interact with my students via EduCitizen (individual environment)	19 (34)	33 (60)	28 (50)	15 (26)	5 (9)
5. I prefer to interact with my students via EduVillage (class-based environment)	22 (40)	34 (61)	29 (51)	9 (16)	6 (10)
6. I prefer to interact with my students via EduTown (school-based environment)	18 (31)	31 (53)	30 (52)	11 (19)	10 (18)
7. Students become more active while using the system	24 (42)	37 (65)	27 (48)	7 (12)	5 (9)
8. I like the multilayer educational services platforms design	33 (59)	43 (76)	18 (32)	3 (5)	3 (5)
9. The EduXs system is easily to use	32 (57)	45 (80)	17 (30)	3 (6)	3 (5)
10. The EduXs system is sufficient for my teaching	21 (38)	42 (75)	23 (41)	9 (15)	5 (9)
11. I would recommend the system to others	38 (67)	41 (73)	14 (24)	3 (5)	4 (7)

1 = Strongly agree; 2 = Agree; 3 = No opinion; 4 = Disagree; 5 = Strongly disagree.

Table 3
Results of the questionnaires given to the students [responses; % (*n*)]

	1	2	3	4	5
1. I use the system in the computer laboratory at school	42 (2349)	29 (1637)	25 (1395)	2 (109)	2 (105)
2. I like the multilayer educational services platforms design	45 (2490)	32 (1775)	19 (1056)	3 (150)	1 (93)
3. Interactions with others are made more frequent by my using the system	31 (1708)	23 (1255)	34 (1908)	7 (363)	5 (289)
4. I prefer to interact with teachers via EduCitiezen (individual environment)	32 (1738)	22 (1236)	35 (1941)	6 (349)	5 (260)
5. I prefer to interact with teachers via EduVillage (class-based environment)	32 (1776)	23 (1285)	34 (1895)	6 (316)	5 (272)
6. I prefer to interact with teachers via EduTown (school-based environment)	30 (1673)	23 (1263)	36 (1994)	6 (324)	5 (264)
7. I use the system at home	51 (2808)	27 (1502)	17 (926)	2 (126)	3 (152)
8. The system helps me in my interactions with classmates	47 (2588)	26 (1447)	22 (1200)	3 (153)	2 (117)
9. I would recommend the system to others	45 (2431)	25 (1388)	25 (1353)	2 (128)	3 (165)

1 = Strongly agree; 2 = Agree; 3 = No opinion; 4 = Disagree; 5 = Strongly disagree.

5. Conclusions

Participants in physical social learning communities, such as schools, classes, and families, often share the same value systems and visions, and frequently interact with others. Learners, especially K-12 learners, spend most of their time in such physical social learning communities. Consequently, the importance of physical social learning communities cannot be neglected in the development of online social learning communities, especially for K-12 learners.

Physical learning communities, such as K-12 learning communities, have unique organizational structures. Online learning communities thus require a structural redesign to reflect physical learning communities.

This work presented a concept known as ''EduXs'', which is a multilayer educational services platforms architecture. Users can establish online social learning communities on the multilayer platforms based on user expectations. Based on physical learning communities, users can build online social learning communities which reflect physical social learning communities. Physical and online learning communities can both be integrated using the EduXs architecture.

A system which is compatible with the EduXs concept has been implemented, and distributed via the Internet for schools, classes, and individuals. Schools can establish school-based online learning communities using the school level EduX, named EduTown. Similarly, classes can establish class-based learning communities using the class level EduX, named EduVillage. Finally, individuals can establish individual-based learning communities using the individual level EduX, named EduCitizen. The different layers of EduXs provide different types of services from service item developers.

From the system evaluation, 45% of Taiwanese schools have applied to use the system. According to the formula for calculating the active EduX layer, 18.8% of these schools are active. The figures on daily total page-views indicate that users use the system both at school and at home. Moreover, the system is used both on weekdays and at weekends. Two questionnaires were sent to users of the system, including both teachers and students. The questionnaires results show that both teachers and students like using the system, and agree that the system can help them to establish online social learning communities. These survey results show that the concept of EduXs is appropriate for Taiwanese schools. The implementation of multilayer educational services platforms is accepted by both teachers and students. More detailed evaluations, particularly quality evaluations, are required in the near future to clarify system performance, based on the judgments of teachers and students.

The EduX platforms require additional learning contents for users to apply to their learning activities. Consequently, the authors are modifying the system according to standards, such as SCORM, and ULF, to open it up to more system developers and integrate it with various other platforms and contents. Currently, only the framework of the EduXs has been completed. Many learning activities, contents, learning tools, and user organization mechanisms remain unimplemented.

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