Development of a sociometric web application to study the relationship among secondary school learners

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This research aimed to develop a sociometric web application to study the relationship among Thai secondary school learners. The first phase studied conditions and needs for a sociometric web application by interviewing 8 teachers (100% females) who have teaching experiences between 3-38 years (Mean = 16.63, SD = 11.58). The second phase developed a sociometric web application which was reviewed by 5 experts and received the overall highest level of appropriateness. Then, the application was piloted with 34 teachers and learners. Overall, the sociometric web application and user manual are suitable for use. The third phase studied results for the sociometric web application usage. Samples included teachers and secondary school learners. The experiment was conducted in a large group of 6 teachers (100% females) having teaching experiences between 4-22 years (Mean = 8.67, SD = 7.03) and students in 5 classrooms, totaling 204 participants (88.73% of response rate, 60.2% females, 39.8% males, age range = 10-23 years old, Mean = 15.72, SD = 1.67) selected via a purposive sampling method. The research tools were the observation form, interview forms, and opinion questionnaire regarding sociometric web application usage. Data were analyzed by qualitative data and descriptive statistics, including frequency distributions, percentages, means, standard deviations, t-test, crosstabs, and chi-square. The teachers' and learners' opinions on web application usage showed an overall highest level of suitability. Furthermore, results concerning the consistency of the sociometric status analysis and the teachers' opinions showed overall average consistency at 87.21%. Finally, the students' sociometric status was divided into five student groups: (1) average (34.3%); (2) popular (24%); (3) neglected (19.1 %); (4) rejected (15.7 %); and (5) controversial (6.9%). Students' gender and academic performance were related to the sociometric status with a .05 level statistical significance (\( \chi^2 = 17.742, \text{sig} = .001 \), \( \chi^2 = 23.831, \text{sig} = .002 \), respectively. This signifies that students of different genders and academic performances had different sociometric statuses.

1. Introduction

The relationship between students and their peers is essential to a happy and successful life at school. Teenagers spend most of their time at school and their “friends” play an important role in their social lives. School life is among the three factors that have emotional effects on adolescents apart from the appearance and relationships with their parents (OECD, 2019). Recent research has found that relationships between students and their peers were related to students in many aspects, such as academic success (Aparisi et al., 2015; Liem and Martin, 2011; Soponaru et al., 2014; Wentzel et al., 2021), participation in school and extracurricular activities (Juvonen et al., 2012; Martin, 2012), friendship among students in academic and non-academic activities (Leung and Silberling, 2006), behavioral and emotional strengths (Rytioja et al., 2019), psychosocial adjustment (Muñoz-Silva et al., 2020), and self-esteem (Liem and Martin, 2011; Reitz et al., 2016). Good relationships with fellow students and a sense of belonging at school result in students feeling happier and more satisfied with their lives (OECD, 2019).

One of the methods used to study the relationship between learners and their peers is the “Sociometry” technique, a tool that provides educators with a valuable knowledge database to optimize the opportunities available in the classroom learning environment (Golovina & Feofanov, 2021). The method was developed by Jacob Levi Moreno (1934) and has been recognized as a scientific method for analyzing the structure of...
human society and measuring interpersonal relationships. However, the limitations of the sociometry method as being a time-consuming and complicated process have resulted in a small number of research studies related to sociometry in Thailand. A review of literature on sociometry in Thailand via ThaiJo, ThaiLIS Digital Collection (TDC), and National Research Council of Thailand (NRCT) found 26 related research. Most of the studies used the sociometry as a research tool to study the student relationships among secondary school students: Nilphangnga (1984), Plabdang (1989) Engkapradit (1990), and Dechma (1999), etc. In addition, other studies observed specific groups such as children with special needs (Ratanapan, 1997; Nimmaul, 2006; Srinaruewan, 2005), gifted children in secondary school levels (Peathanhom, 2000), and adolescents with broken families (Klinsutto et al., 2012), etc. Much research applied sociometry with 1–4 situations and defined the number of options from 2-5 choices. However, the study of sociometry which provides both positive and negative situations at once and uses the criteria to interpret the students’ sociometric status was not found. Also, the use of web applications to explore the relationship among students in Thailand was not noticeably found.

As mentioned above, with the increasing trend of information and communication technology usage in teaching and learning, researchers are furthering their study in research related to the use of computers to measure sociometry. A study by Cillessen and Marks (2017), van den Berg and Cillessen (2013), and Erendjik and Cillessen (2015) found that the use of a computer was interesting, time-saving, and cost-effective. It helped minimize probable errors and could securely store confidential information. It is suitable for long-term studies and is more efficient than the paper-based method. This is consistent with studies by A. Hussein and Hilmi (2020) who found that cloud-based web applications had prominent features of convenient access to network management, storage database, and administration of web applications. In addition, users do not have to invest in building and maintaining information technology-related infrastructures.

This is in line with the notion by Thailand’s Ministry of Information and Communication Technology (2011) who proposed a policy on the application of information and communication technology in 2011–2020 to enhance lifelong learning by promoting innovation in teaching and learning through the application of information technology. The adoption of mobile electronic devices has transformed learning to occur anywhere and anytime through a variety of mobile devices (Khalfaisang and Mingsrittham, 2016) while an application is one of the options that educational institutes employ to develop Thai education and increase teaching and learning efficiency. This is made possible via internet networks which are used as a resource to promote learning without limitations of time and place.

From the aforementioned significance and necessity coupled with the readiness of information and communication technology of schools, the teachers and students in secondary education who can connect smartphones and tablets to the internet, the researcher recognized the importance of developing a system for collecting and analyzing sociometric data by using a web application to provide convenient and time-saving operations.

1.1. Research objectives

1. To study the conditions and needs of using a sociometric web application to study the relationship among secondary school learners.
2. To develop a sociometric web application to study the relationship among secondary school learners.
3. To study the usage results of a sociometric web application to study the relationship among secondary school learners.

2. Literature review

2.1. Sociometry

“Sociometry” is a method for studying the social relationship of learners with their peers. In the process, students assess their feelings towards their peers under the circumstances of being together or undertaking a particular activity together. The information obtained from the sociometry study will help teachers and learners understand the relationship structure between learners and peers in the selected social group, including the number of subgroups, the nature of the relationship among the groups, and the characteristics of each subgroup (Babad, 2009; Cruz et al., 2018; Moreno, 1951).

From the study on the operation methods and the classification criteria of the sociometric status, the researcher adopted the sociometry method in studying the relationship between learners according to the concept of Moreno (1934). Then, the collected data is provided by students proposing the name of a classmate who they wish to join their group in different situations. The relationship was divided into two dimensions, a classmate who the student wishes to join the group most and a classmate who the student wishes to join the group least. This method provided better results than the mean method in terms of behavioral classification (Terry and Coie, 1991) which used the values of social preference and social impact (Peery, 1979) and the classification criteria of the sociometric status (Coie et al., 1982) which categorizes social status by social preferences and social impact into five aspects namely those who are accepted by many peers (popular), those who are rejected (rejected), those who are liked and disliked by peers (controversial), those who are neglected (neglected), and those who have average peer relationships (average). The study of Coie found that “outward attractiveness” and “peer support” was a good predictor of social preference while male students were more likely to be rejected. This trend was seen across all age groups.

In this study, the researcher created a sociometric system. The process of creating the sociometric tool was divided into 7 steps: (1) determining the target group to be studied; (2) determining the selection situation; (3) familiarizing with the study group; (4) collecting data by a sociometric system; (5) creating a sociometry table; (6) developing a sociometry map; and (7) interpreting a sociometry map (Suraseth, 2019).

The development of the sociometric web application to study the relationship among secondary school learners which followed the aforementioned 7 steps helped save time in the data processing and analysis process. Additionally, the analysis results were more accurate. It facilitated teachers and users in each step and was able to easily and quickly store and retrieve data. The data obtained can be used for research studies with other relevant variables to expand knowledge for further development of the relationships between learners.

2.2. Sociometry application

The researcher studied existing sociometry applications, including GroupDynamics, SociometryPro, and Sociogram 5.1. The study revealed that GroupDynamics is a program for processing data obtained from the sociometry test acquired as students learn in various subjects. The results from the graph can assess the social dynamics within the group of learners. The program was designed for efficient and simple user interaction. Thus, the data entry process is convenient while the analysis results are displayed in graphs for quick analysis and evaluation. Graphs can be displayed in various forms, including bar graphs, goal graphs, and sociometry analysis results (Capretti, 2012).

SociometryPro is a program that can evaluate and display sociometric test results. It also presents the information in suitable displays and formats such as the sociometric matrices, indexes, graphs, and the target perspectives for operating the sociometric data. This program is useful to psychologists, human resource managers, and teachers. It can also increase productivity (LeDiS Group, 2013).

Sociogram 5.1 is a web application with the design based on the sociometry concept by psychiatrist Jacob Levi Moreno (1934) to analyze emotional relationships between individuals within groups. This application can add, store, and edit sociometric data into a database and analyze the results into various graphic formats. Data can be analyzed and displayed in four different sociogram formats. Moreover, users can...
interact with the results using the graphic and diagram formats to study and edit information by moving the “nodes” in the display area. The information can be published or sent as an email attachment (MGA in Krimar.si, 2005).

According to the review on existing applications, the main limitations uncovered were: (1) the inability to analyze the social status of individual learners; (2) the lack of regular updates; (3) outdated interface design; and (4) only support the use with personal computers. Therefore, in the design and development of a sociometric web application, the researchers developed a responsive web application that is compatible with all devices through a web browser where users do not need to install a program. As for the developers, they can easily maintain the system to be up to date. Moreover, the application is user-friendly and, when in use, teachers can ask students to access the web application via a PIN or QR code and promptly answer questions during class.

2.3. The development of a sociometric web application

Based on the study by Batory et al. (1994), Larman (2004), Molina-Rios and Pedreira-Souto (2020), and Denard et al. (2020), the development cycle of the information system used in the design and development of a sociometric web application to study the relationship among secondary school learners were divided into 4 important steps: (1) the analysis phase aims to survey existing data by studying obtainable data and reports, observing the operation methods, and conducting interviews; (2) the design phase seeks to use the analysis results and collected data to design the system; (3) the development phase uses all the design data to create a program according to the design plan; and (4) the implementation phase uses, tests, and improves the developed program.

Additionally, from the study of web design guidelines and web application development, the guidelines can be summarized as follows: (1) having clear objectives; (2) having well-structured and quality design; (3) having interactivity with users and are easy-to-use; and (4) showing the identity of the organization and meeting international standards (Gunawan et al., 2017; Labib, 2017; Waterhouse, 2005).

In evaluating the web application in this research, being an instructional web application, the researcher applied the concept of an instructional web application evaluation. One of the key principles of the instructional web design is continuous evaluation and improvement which consists of formative and summative evaluation. The summative evaluation consists of two steps: (1) evaluating the internal features of the instructional website by experts and (2) evaluating the quality of the instructional website by testing with learners in sample groups, including the one-to-one test, small-group test, and large-group test (Khlaissang and Koraneekj, 2016).

3. Research methods

This is a research and development study to develop a sociometric web application to study the relationship among secondary school learners. The research process is divided into 3 phases. In every phase of the research, the information of the key informants is kept confidential and informed consent was obtained from all informants of the experiment. The results of the research will only be presented as an overview, without information that may lead to the identity of the key informants. The details of each research phase are as follows.

The research was consented by the Research Ethics Review Committee for Research Involving Human Subjects: The Second Allied Academic Group in Social Sciences, Humanities and Fine and Applied Arts at Chulalongkorn University in order to obtain the ethnical approval. Therefore, there are the Certificate of Research Approval numbers (COA No.) in each phrase evidently which are Phase (1) COA No. 072/2563, Phase (2) COA No. 152/2563, and Phase (3) COA No. 001/2564.

3.1. Phase 1: A study of the conditions and needs of a sociometric web application to study the relationship among secondary school learners

The key informants for the interviews were 8 teachers (100% females) selected via a purposive sampling method that met 4 inclusion criteria. For more clarification, 6 teachers were guidance teachers at the secondary level under the Basic Education Commission (OBEC) in Thailand (75%), and the other guidance teachers were affiliated with the Ministry of Higher Education, Science, Research, and Innovation in Thailand (25%). Furthermore, most of the respondents hold a master’s degree, 6 teachers (75%), another teacher held a doctoral degree (12.5%), and another respondent held a bachelor’s degree (12.5%). All of the teachers have the teaching experiences between 3—38 years (Mean = 16.63, SD = 11.58), and have been applying sociometry in their classroom for 3—30 years (Mean = 10.63, SD = 9.91).

The researcher used the interview form for the teachers’ opinions, inquiring about their needs, using methods, and a model of a sociometric web application that is suitable for developing a sociometric web application. The researcher studied the concepts, theories, and related research prior to defining the conceptual framework and scope of the questions. The opinion interview form was reviewed for its content and assessed using the Index of Objective Congruence (IOC) by three experts. Each question item passed the criteria fit for data collection from the samples and the experts’ recommendations were used to improve the questions. After data collection, the researcher conducted a content analysis and synthesized the obtained information to summarize the use of the sociometric web application.

3.2. Phase 2: The development of a sociometric web application to study the relationship among secondary school learners

In this phase, data from Phase 1 and the literature review of the documents and related research were used to develop the web application. The researcher designed the structure of the sociometric web application and samples of screenshots of the sociometric web application. Then, they were examined by 5 experts for their suitability based on the assessment criteria for the sociometric web application structural design and screenshot samples. Every item passed the IOC criteria fit for data collection and the recommendations were used to improve the application.

As the newly developed sociometric web application has never been used, the researcher chose to perform a pilot test for usability testing. The key informants’ schools were selected via purposive sampling that met 5 inclusion criteria. The tests were divided into a one-to-one test consisting of a teacher and 3 learners with high, medium, and weak computer skills, a small-group test consisting of a teacher and 6 learners, and a large-group test consisting of a teacher and 25 learners.

The researcher utilized the observation and interview form in using the sociometric web application of teachers and students. Also, a sociometric web application assessment form was used to study the relationship among secondary school students. All the questions used in the data collection process had IOC values that passed all criteria and recommendations were provided for further improvements. Moreover, interviews with the teachers and students were conducted after they used the sociometric web application and user manual. Then, the obtained information was used to improve the sociometric web application and user manual.

3.3. Phase 3: The study on the using results of a sociometric web application to study the relationship among secondary school learners

The sample was obtained by a purposive sampling method that met 5 inclusion criteria. Data collection was conducted with the sample of teachers and students from 4 schools, comprising a total of 6 teachers and
students in 5 classrooms, totaling 204 students. However, the respondents were 181 out of 204 students (88.73% of response rate) who answered the questionnaire about the use of the sociometric web application. The students were divided into 72 males (39.8%) and 109 females (60.2%) having an age range between 10-23 years old (Mean = 15.72, SD = 1.67). To clarify, most of the students, 48 students, were younger than 15 years old (26.6%), followed by 43 students who were 16 years old (23.8%) and 39 students who were 15 years old (21.5%). There were also 103 upper secondary school students (56.9%) and 78 lower secondary school students (43.1%). Additionally, there were 6 teachers (100% female) with the teaching experience between 4-22 years (Mean = 10.32, SD = 7.54). To clarify, most of the students, 48 students, were younger than 15 years old (26.6%), followed by 43 students who were 16 years old (23.8%) and 39 students who were 15 years old (21.5%). Additionally, there were 6 teachers (100% females) with the teaching experience between 4-22 years (Mean = 10.32, SD = 7.54), of which three were less than 31 years old (50.0%). Also, they have the highest educational background at the master's degree level and the bachelor's degree level at the same number (three teachers in each level).

The researcher used the observation and interview form in using the sociometric web application of teachers and learners, developed during Phase 2, and a questionnaire on the use of the sociometric web application. The questionnaire is divided into the teacher version and the student version. The student version was tested with 30 students who had similar demographics to the sample. The reliability value was determined using the Cronbach Alpha Coefficient formula with a value of 0.889. Then, the researcher conducted content analysis from qualitative data obtained by observing the use of the sociometric web application. Data from the opinion questionnaires about the use of the sociometric web application was analyzed using descriptive statistics. The mean comparison of the opinions about the sociometric web application usage among participants' gender, education level, and school affiliation was analyzed using the t-test method. Moreover, the relationship of the sociometric status was analyzed by using the two-way frequency distribution or crosstab analysis and the chi-square test.

Afterward, the researcher applied the obtained results to improve the sociometric web application and user manual. Finally, the final sociometric web application and user manual were completed for the presentation of the sociometric web application to study the relationship among secondary school learners.

4. Research results

4.1. The research results in phase 1: A study of the conditions and needs of a sociometric web application to study the relationship among secondary school learners

Found that the key informants saw that the sociometric web application facilitated the study of the relationship among learners while using an accurate and convenient sociometric method. The key informants agree with the development of a sociometric web application because it would facilitate teachers to use more sociometric methods in the class. The web application can be applied to all levels of learners and help reduce the time in conducting sociometric studies. The questions in the four sample situations were found to be appropriate for studying the relationship among learners

In addition, the study of existing applications found significant limitations such as (1) the inability to analyze the social status of individual learners; (2) the lack of regular update; (3) outdated interface design; and (4) only support the use with personal computers.

Therefore, in the design and development of a sociometric web application, the researchers developed a responsive web application to be compatible with all devices through a web browser where users do not need to install a program. As for the developers, they can easily maintain the system to be up to date. Moreover, the application is user-friendly and, when in use, teachers can ask students to access the web application via a PIN or QR code and promptly answer questions during class.

4.2. The research results in phase 2: The development of a sociometric web application to study the relationship among secondary school learners

4.2.1. The results of the development of the sociometric web application and user manual

The CU Smart Sociometry web application can be accessed via a web browser at the URL: https://socio.edii.in.th. The development of the application employed a hybrid technology with the framework called MeteorJS which is a framework for the Javascript language. Using MeteoJS enabled quick development because it uses Javascript language to develop both the front end for the user interface and the back end which acts as the application server. Furthermore, the client/server architecture was used through the communication channel HTTP and web socket. The client contacts the server through the web browser via HTTP to display the web page. Then, the contacts are completed through the web socket to request information from the database for display on various components of the web page. The client/server architecture is described in a diagram (Figure 1) and the structure of the web application is shown in Figure 2.

Users of the CU Smart Sociometry system are divided into 3 levels namely: (1) the admins who have the right to manage the system and user settings; (2) the teachers who have the permission to view the screen display with a menu to choose among four main functions: user, classroom, questionnaire, and diagram; and (3) the students who have only one access which is for the questionnaire.

In addition, the CU Smart Sociometry allows teachers to manage classrooms and the questionnaires (Figure 3). Also, frequencies of the sociometric status can be distributed in a Sociometry table (Figure 4) and interpreted into various social dimensional diagrams and categorized as: (1) Sociogram by gender (Figure 5), (2) by frequency (Figure 6), and (3) by group (Figure 7). Moreover, the individual and classroom sociometric status can be interpreted in the table as shown in Figure 8.

4.2.2. The experts’ evaluation results for the sociometric web application

According to the reviewing results of the sociometric web application and user manual by five experts who examined the appropriateness using the assessment form of the sociometric web application to study the relationship among secondary school learners, their recommendations were used to improve the application and make the web application fully complete. The evaluation results from the experts found that overall, the application was appropriate at the highest level (Mean = 4.63, SD = .55), with additional suggestions and improvement issues as follows in Table 1.

4.2.3. The results of the usability test of the sociometric web application

In testing the sociometric web application and user manual, the researcher and/or the teacher observes the usage. Then, after the teachers and students use the web application and user manual, the researcher interviewed the teachers and students based on the observation and uses the interview form on the use of the sociometric web application of teachers and students. Finally, the opinions and information from the observations and interviews were used to improve the sociometric web application and user manual.

The content analysis results from qualitative data obtained from observing the use of the web application and the interview results from the volunteer teachers and students led the researcher to uncover problems and to modify the sociometric web application as follows: (1) fixing the function of the web application to work properly and to not cause the web application to reload; (2) fixing the display in the message box to display correctly; (3) removing the friends' name when it has already been selected for a situation, this is to prevent duplicate selection errors; (4) adding a function to allow students to type the student's name and the system will filter the name list of students that exists in the system; (5) fixing the web application to display the report correctly; (6) training the teachers and identify in the user manual of the problems that may arise so
that teachers have a solution to the problem and can enable students to efficiently use the sociometric web application; (7) identifying and clarifying the application that works well with the web application. As the Chrome application is available on Android and Windows devices while Safari is available on iOS and MacOS. Thus, the application is compatible with all devices; (8) fixing the QR code so it can be scanned; and (9) adjusting the PIN code to be a 6-digit numeric code, which makes it more convenient.

4.3. The research results in phase 3: The study of the usage results of a sociometric web application to study the relationship among secondary school learners

The results were divided into 4 issues (3.1) the readiness of the teachers and students to access the devices (3.2) the relationship between gender and academic performance and the sociometry (3.3) the opinions of the teachers and students in using the sociometric web application;
and (3.4) the consistency in the interpretation of the sociometric web application and the teachers’ opinions.

4.3.1. The readiness of teachers and students in accessing the devices

There were 181 out of 204 students, accounting for 88.73%, who answered the questionnaire about the use of the sociometric web application. The students were divided into 72 males, accounting for 39.8%, and 109 females, accounting for 60.2%. There were 6 teachers in the sample group. All of them were female, of which three were less than 31 years old, accounting for 50.0%. An equal portion of them had the highest educational qualifications at the master’s degree level and the bachelor’s degree level.

Considering the experience in using technology devices, the study found that 99 students had a personal computer for use at home, accounting for 54.7%, while the other 82 students, accounting for 45.3%, did not have a personal computer for use at home. In terms of the internet connection for the computer, the personal computer belonging to the 99 students could all connect to the internet, accounting for 100.0%. As for the ownership of a smartphone/tablet for use, the study found that 173 students, accounting for 95.6%, owned a personal smartphone/tablet. Moreover, the smartphone/tablet of the 168 people, accounting for 97.1%, could connect to the internet. As for the devices that students used to access the sociometric web application, 88 students used Android smartphones, accounting for 48.6%, followed by 47 students who used iPhones, accounting for 26.0%. There were 17 students who used desktop computers, accounting for 9.4%, and 15 students who used laptops, accounting for 8.3%, respectively.

Considering the access to the devices to organize the learning activities, the study found that all the teachers had a personal computer and smartphone/tablet for use. Also, both the devices, the computer and smartphone/tablet, could connect to the internet.

4.3.2. The relationship between gender and academic performance and sociometry

The analysis of students’ sociometric status classified by their academic performance can be divided into the strong group (GPA 3.50 or higher), the moderate group (GPA 2.51–3.50) and the weak group (GPA less than 2.51). The results in Table 2 showed that academic performance was related to social status with the statistical significance at the .05 level ($\chi^2 = 23.831$, sig = .002). The weak group was in the group of students who were most rejected by their peers (44.4%). The moderate group was
mostly in the average relationship group (38.8%). As for the smart group, they were mostly in the popular group (38.6%). The analysis showed that students with different grades would have different sociometric statuses.

The effect size of the relationship between the academic performance and sociometric status is significantly related ($d = 0.34$). Consequently, the students with different grades would have different sociometric statuses.
Furthermore, the analysis of the students’ sociometric status as shown in Table 3 which is classified by gender, found that the students’ gender was related to their sociometric status with the statistical significance at the .05 level ($\chi^2 = 17.742, \text{sig} = .001$). The male students were mostly in the average group (39.3%), followed by the popular group (20.2%) and the rejected group (20.2%). The female students...
A study of the students' opinions about the overall use of the sociometric web application found that the students' opinions were at the highest level (Mean = 4.52, SD = .44). When considering each item individually, it can be seen that students were willing to help their peers in using the sociometric web application when problems occur. Moreover, students viewed that the sociometric web application was properly designed and felt satisfied in using the sociometric web application at the highest level (Mean = 4.56, 4.56, 4.56; SD = .66, .61, .58). This is followed by the perception that the sociometric web application was designed to be easy and convenient to use (Mean = 4.55, SD = .60), cost-effective (Mean = 4.55, SD = .59), students feeling happy when using the sociometric web application, and the use of the sociometric web application was as expected (Mean = 4.54, 4.54, SD = .51, .63), respectively.

The analysis of the differences in opinions about the use of the sociometric web application when classified by the educational level found that the students' average opinions had differences with the statistical significance at the .05 level (t = 2.126, sig .035). The study shows that the students in secondary school had higher opinions about the use of the sociometric web application than those in high school (Secondary school: Mean = 4.59, SD = .38; High school: Mean = 4.46, SD = .48). However, when analyzing the differences in opinions about the use of the sociometric web application classified by gender and school affiliation, the study found that the students' opinions had no differences with the statistical significance at the .05 level (Gender: t = -.589, sig = .557; School affiliation: t = -1.479, sig = .141). According to the effect size of gender, class, and school affiliation on the students' opinion of the sociometric web application, the study found that gender and school affiliation was not related to the students' views. Meanwhile, the class influenced the student's opinions at a small level (d = .20).

### 4.5.4. The consistency of the interpretation by the sociometric web application to the teachers' opinions

The analysis of the consistency of the sociometric status analysis results to the teachers' opinions was conducted by having the teachers recheck the correctness of the analysis data of the sociometric status that the program analyzed. The results of the consistency analysis of the sociometric status to the teachers' opinions found that the overall results were consistent (87.21%). When considering each school individually, it can be seen that the sociometric status analyzed by the program was consistent with the opinions of the teachers. The percentages were between 81.08%-97.50%, indicating that the sociometric status information that was processed by the application and the teachers' feedback were highly consistent.

### 5. Discussion

#### 5.1. The development of the sociometric web application

The researcher developed the sociometric web application in the form of a responsive web so that the web application can be displayed appropriately on different devices. Therefore, the newly sociometric web application was invented through 7 processes of creating the sociometric: (1) determining the target group to be studied; (2) determining the selection situation; (3) familiarizing with the study group; (4) collecting data by a sociometric system; (5) creating a sociometry table; (6) developing a sociometry map; and (7) interpreting a sociometry map (Suraseth, 2019). Additionally, the web application followed 4 important steps of the design and development of a sociometric web application: (1) the analysis phase that aims to survey existing data by studying obtainable data and reports, observing the operation methods, and conducting interviews; (2) the design phase that seeks to use the analysis results and collected data to design the system; (3) the development phase that uses
Table 2. The analysis of the relationship between the academic performance and sociometric status.

| Academic performance | Sociometric status | Total       |
|-----------------------|-------------------|-------------|
|                       | rejected           | neglected   | average | controversial | popular |
| Weak                  | 8 (44.4)          | 3 (16.7)    | 5 (27.8) | 2 (11.1)       | 0 (0.0) |
| Moderate              | 19 (14.7)         | 25 (19.4)   | 50 (38.8)| 8 (6.2)        | 27 (20.9) |
| Strong                | 5 (8.8)           | 11 (19.3)   | 15 (26.3)| 4 (7.0)        | 22 (38.6) |

χ² = 23.831; df = 8; sig = .002

Table 3. The analysis of the relationship between gender and the sociometric status.

| Gender | Sociometric status | Total       |
|--------|-------------------|-------------|
|        | rejected           | neglected   | average | controversial | popular |
| Male   | 17 (20.2)         | 7 (8.3)     | 33 (39.3)| 10 (11.9)     | 17 (20.2) |
| Female | 15 (12.5)         | 32 (26.7)   | 37 (30.8)| 4 (3.3)       | 32 (26.7) |

χ² = 17.742; df = 4; sig = .001

all the design data to create a program according to the design plan; and (4) the implementation phase that uses, tests, and improves the developed program (Batory et al., 1994; Larman, 2004; Molina-Ríos and Pedreira-Souto, 2020; Denard et al., 2020). Also, the guidelines can be summarized as follows: (1) having clear objectives; (2) having well-structured and quality design; (3) having interactivity with users and are easy-to-use; and (4) showing the identity of the organization and meeting international standards (Gunawan et al., 2017; Labib, 2017; Waterhouse, 2005).

This was consistent and responded to the opinions of the teachers and students in the study of the conditions and needs of the sociometric web application. The results in Phase 1 which studied the readiness of the teachers and students showed that 98.75% of the teachers had a computer/notebook and 97.13% of the students had a smartphone that can connect to the internet. Therefore, the development of the web application to be compatible with all devices will help respond to the readiness of the teachers and learners. This is in accordance with the initiative by Ministry of Information and Communication Technology (2011) which proposed a policy on the application of information and communication technology to enhance lifelong learning (smart learning) by promoting innovation in teaching and learning through the application of information technology. This can be carried out by adjusting the teaching and learning processes to respond to the development of mobile devices.

The results of the study found that users were satisfied with the sociometric web application. This may be because it saves time in the data analysis process and the creation of the sociometric diagrams. Also, the sociometric web application is applicable to all educational levels. They also observed that the results of the sociometric diagrams from the web application provided information that was consistent with the actual situation. Moreover, the study of teachers’ opinions found that, overall, the web application was appropriate at the highest level. This is consistent with the results of a study on the development of various forms of web services. Taherdoost (2018) studied the user acceptance of electronic services using the E-Service Acceptance Model (ETAM). The study found that quality, safety, user-friendliness, and satisfaction had a strong influence on the willingness to use electronic services. Another study by Ranellucci et al. (2020) found that the behavioral intention to use technology had variables of perceived benefit, attitude about computers, intention to use, values, and supporting environments. The study found that the components that should be supported were the creation of an environment that supported the use of technology.

Likewise, the researcher examined the validity of the information from the web application which classified learners into five groups according to the criteria of Coie et al. (1982, as cited in Marengo et al., 2021). The overall results were found to be consistent. Furthermore, when considering each classroom individually, the study found that the sociometric status analyzed from the web application was consistent with the opinions of the teachers. The research showed that the sociometric status processed by the web application and the teachers’ opinions were highly consistent.

Also, the results of this study were consistent with the ongoing efforts of scholars to study the sociometric measurement tools. Some examples include a comparative study of the validity and reliability of the computer-based and paper-based sociometric measurements by van den Berg and Cillessen (2013). Additionally, another study of the computerized sociometric assessment by Endeldijk and Cillessen (2015) and Kuz (2017) investigated the development of ICTs by creating a web tool called the Agent SocialMetric. The study of the computerized sociometric assessment (Endeldijk and Cillessen, 2015) found that computer-based sociometric measurements were more efficient.

5.2. The use of sociometry to study the social relationships among learners

Using sociometry to study the relationships among 204 second-year school and high school students, the researcher chose the peer nomination method based on the concept of Moreno (1934) and the criteria of Coie et al. (1982, as cited in Marengo et al., 2021) to assess the students’ sociometric status by using a questionnaire. There were four scenarios for the students to nominate three peers wherein the data will be used to group the students according to the five types of sociometric statuses. The study found that students had the sociometric status in the following order: (1) average students (34.3%); (2) popular students (24%); (3) neglected learners (19.1%); (4) rejected students (15.7%); and (5) controversial students (6.9%). This is consistent with the results in a study by Marengo et al. (2021) that examined the sociometric status among the sample of 1,742 primary and secondary school students from 113 classrooms (47.2% female, mean age 10.79). There were five types of sociometric status as follows: (1) average students (33.4%); (2) popular students (27.5%); (3) rejected students (21.4%); (4) neglected students (14.2%); and (5) controversial students (3.6%). The results were different only in the ranking of the 3rd and 4th place.

The results of previous research on the reasons for nominating least favorite classmates can be divided into 3 main issues: (1) habits including verbal expression and behaviors such as aggression, violence against others, egotism, antisocial, and interfering with the welfare of others; (2) personality including tastes and personal preferences; and (3) ignorance including the lack of interaction with others, not participating in the activity due to unfamiliarity, and not talking to others (Garcia Garcia Bacete et al., 2021).

Based on the findings, the teachers and educators should provide special assistance to rejected students because they have the opposite characteristics to popular students in every way (Coie and Dodge, 1983). The rejected students usually have behavioral issues, therefore, they are
rejected by their peers (French, 1988). They have less life satisfaction, communication skills (van der Wilt et al., 2019). Moreover, the rejected status tends to persist even as time passes and it is observed that the behaviors that may predict the sociometric status and social preference are cooperativeness, disruptiveness, and proneness to initiate fights (Coie et al., 1982).

In addition, the results of the analysis of the sociometric status of learners classified by gender found that the gender of students was related to the sociometric status with a statistical significance at the .05 level ($\chi^2 = 17.742$, sig = .001). The analysis showed that students of different gender had different sociometric statuses. The findings are consistent with research by Ato et al. (2014) and Martín and Soto-Soto (2020) which found that boys were more socially rejected than girls. Self-control was a latent variable of gender and rejection from peers while parenting was a latent variable of self-control.

Finally, the results of the analysis of the students’ sociometric status classified by their academic performance were divided into the strong group (GPA 3.50 or higher), the moderate group (GPA 2.51–3.50), and the weak group (GPA less than 2.51). The results showed that the students with different academic performances had different sociometric statuses. Moreover, the social acceptance of peers had a positive significant correlation with the academic performance of moderate and high score learners. Also, the higher scores varied inversely with the age of the learners, most of which were from Asian countries, and a classroom that focused on the assessment of academic performances (Wentzel et al., 2021).

6. Limitation

Since the research was carried out during the COVID-19 pandemic, the interview and meetings needed to be conducted via telephone, Line or Zoom applications depending on some of the informants’ preferences. Therefore, the researchers were not able to notice the informants’ non-verbal reactions thoroughly throughout the interview. However, the researchers and the informants examined the validity of the information from the web application before sharing information.

7. Recommendations

7.1. Recommendations for research results applications

In setting the situation, the teachers and users can choose from the sample situations or assign new situations. The situation should cover the context of peer selection which may vary as the situation alters. For example, the teachers should set the proper circumstances of peer selection in both the learning and non-learning contexts in order to study and assess the students’ relationships accurately and comprehensively.

The interpretation results of the sociometric status in this study were based on the criteria of Coie et al. (1982, as cited in Marengo et al., 2021) as a guideline for grouping the learners. The teachers and users should consider the results in conjunction with other additional information, such as observing students’ relationships via real contexts or asking their peers, parents, teachers, and other related people, etc.

The teachers and users should use the sociometric web application to explore the relationship of learners in each classroom at least once per academic year and use the results to assist students, especially students who are in the rejected and neglected group. Furthermore, the psychological counseling, social skill activities, or positive environments should be also provided for the students.

The sociometric web application can be applied in the on-site and online contexts by adjusting with altering situations. However, utilizing the sociometric web application also depends on users’ ICT readiness in terms of approachable devices and skills. For example, Brazil Araújo and Dias (2019) studied a sociometric analysis for the creation of an integrated multicultural work team analyzed by the Kumu software. In the sequence, the sociometric analysis of the participants’ interrelationship designed the best scenario of teamwork and leadership for the working team so that they were able to work together without conflicts. Moreover, in the cast of rejected person, the sociometric analysis could appropriately choose and move the student to another group with acceptance.

7.2. Recommendations for further studies

The researcher should study the sociometric status together with other characteristics variables of learners in order to see the relationship of learners’ characteristics in various aspects through self-assessment and assessment by peers and teachers.

The researcher should study the results of the limited and unlimited nominations which, originally, were used differently. The limited number of nominations were applied to quantitative research and used approximately 3–5 names due to technological limitations. However, the use of unlimited nominations may prompt students who do not want to answer to choose “everyone” instead. Therefore, a maximum number of names should be set (Cillessen and Marks, 2017).

The researcher should study the order of the name list because two studies found that students whose names were listed at the top of the list were often chosen in the research that allowed multiple nominations (Poulin and Dishion, 2008). Thus, this shows that the replies can be biased, even though it is at a low level. Thus, this shows that the replies can be biased, even though it is at a low level. However, the randomized name list also causes informants to have difficulty selecting their peers (Cillessen and Marks, 2017).

Declarations

Author contribution statement

Chutima Suraseth and Prakob Koraneekij: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

The authors do not have permission to share data.

Declaration of interest’s statement

The authors declare no conflict of interest.

Additional information

The clinical trial described in this paper was registered at COA under the registration numbers which are Phase (1) COA No. 072/2563, Phase (2) COA No. 152/2563, and Phase (3) COA No. 001/2564.
Appendix

Interview guidelines for the use of the sociometric web application—Phase 1

1. How often had you used the sociometric technique to study the relationships among the students?
2. What grades of students have you used the sociometric technique to study their relationships?
3. What are the steps when you use the sociometric technique?
4. When using the sociometric technique, what problems or obstacles do you encounter?
5. What do you think are the factors contributing to the relationships among the students (ex. gender, grade level, learning outcome, questions in a situation, etc.)?
6. Do you think that the 7 sociometric technique steps are complete and cover all the areas of the sociometric technique process and why?
7. Do you think that the following situation is appropriate for measuring the relationships among the students and why?
8. When the teachers can select a situation in an academic setting (situation 1 or 2) and select another situation that is not related to the academic setting (situation 3 or 4) or the teachers may create a new situation, do you think this is appropriate and why?
9. Do you think that the interpretation of the students’ sociometric status that is categorized into 5 types according to Coie et al. (1982) is complete and covers all the related areas and why?
10. Can the sociometric web application facilitate the study of the relationships among students by using the sociometric techniques in a valid, reliable, and convenient approach, and at what level?
11. Does the teacher have a personal computer/notebook and smartphone/tablet for work that can connect to the internet and at what proportion?
12. Does the student have a smartphone for work that can connect to the internet and at what proportion?
13. Do you have any further suggestion that is related to the development of the sociometric web application and why?

Evaluation for the sociometric web application site structural design and interface of the sociometric web application development for the study of the relationships among secondary school students (Expert’s version)—Phase 2

Point of evaluation for the sociometric web application site structure and interface

1. Web application site structure
2. Web application interface design
   2.1 It is easy to read the selected fonts.
   2.2 The selected font size is appropriate and can easily be read when placed over the background.
   2.3 The symbols and buttons are within normal standards and can easily be understood.
3. Web application usability design
   3.1 Registration to the system with emails or Google ID
   3.2 The web application log-in for the teachers is convenient.
   3.3 Creating a classroom, importing students’ names to the system, and creating a PIN for students
   3.4 Logging in the system and students entering the classroom via PIN
   3.5 Creating positive and negative questions
   3.6 It is simple and convenient for students to reply.
   3.7 Creating reports in PDF, Word, and Excel (CSV) files format
   3.7.1 Calculating students’ selections frequencies and generating outcomes in a table format with interpretations according to the criteria
   3.7.2 Presenting the sociogram according to the frequencies with the use of bold lines as first, solid lines as second, and dashed lines as third selections

Observation and interview guidelines for the usability of the sociometric web application for teachers and students—Phase 2 and 3

The usability of the application.

1. Registration to the system with emails or Google ID
2. The web application log-in for the teachers is convenient.
3. Creating a classroom, importing students’ names to the system, and creating a PIN for students
4. Logging in the system and students entering the classroom via PIN
5. Creating positive and negative questions
6. It is simple and convenient for students to reply.
7. Creating reports in PDF, Word, and Excel (CSV) files format
   7.1 Calculating students’ selections frequencies and generating outcomes in a table format with interpretations according to the criteria.
   7.2 Presenting the sociogram according to the frequencies with the use of bold lines as first, solid lines as second, and dashed lines as third selections.

Interview guidelines

1. Following the sociometric web application usability test, is it convenient and user-friendly? Please elaborate.
2. What are the problems that you encountered when using the sociometric web application?
3. Additional comments

Questionnaire on the opinion towards the use of the CU Smart Sociometry (teacher’s version)

Part 1 Demographic information

1. Gender
2. Age
3. Highest education level
4. Name of school
5. Subject taught during the activity. Student’s grade level. Number of students
6. Teaching experience (years)
7. Do you own a personal computer for work?
8. If you own a personal computer, can it connect to the internet?
9. Do you own a smartphone/tablet for work?
10. If you own a smartphone/tablet, can it connect to the internet?

Part 2 Opinion towards the use of the CU Smart Sociometry

1. You are willing to use the CU Smart Sociometry to study the relationships among the students.
2. You acknowledge the significance of using the CU Smart Sociometry to study the relationships among the students.
3. You are enthusiastic to learn how to use the CU Smart Sociometry to study the relationships among the students.
4. You think that the CU Smart Sociometry helps in the study of the relationships among the students.
5. You are willing to answer questions about the use of the CU Smart Sociometry when students encounter problems while using the web application.
6. You feel satisfied when you see that students are enthusiastic about using the CU Smart Sociometry.
7. You think that the CU Smart Sociometry has been appropriately designed in areas such as images, fonts, colors, icons, buttons, and hyperlinks.
8. You think that the questions available in the CU Smart Application are appropriate.
9. It is worth using the CU Smart Sociometry.
10. You can learn how to use the CU Smart Sociometry on your own by reading the manual.
11. You can use the CU Smart Sociometry according to your requirements.
12. The CU Smart Sociometry can help you study the relationships among the students.
13. When encountering problems while using the CU Smart Sociometry, you can seek solutions on your own.
14. Your students can use the CU Smart Sociometry.
15. The CU Smart Sociometry was designed to be user-friendly and convenient.
16. You are satisfied with the use of the CU Smart Sociometry.
17. You will use the CU Smart Sociometry with other students in the future.
18. You will recommend your colleagues to use the CU Smart Sociometry to your colleagues.
19. You can communicate your experience regarding the use of the CU Smart Sociometry to your colleagues.
20. The generated sociogram from the CU Smart Sociometry provides information that is associated with the actual situation.

Questionnaire on the opinion towards the use of the CU Smart Sociometry (student's version)

Part 1 Demographic information
1. Gender
2. Age
3. Name of school
4. Grade level
5. Do you own a personal computer for work at home?
6. If you own a personal computer for work at home, can it connect to the internet?
7. Do you own a smartphone/tablet for work?
8. If you own a smartphone/tablet for work, can it connect to the internet?
9. In what device was the CU Smart Sociometry used?

Part 2 Opinion towards the use of the CU Smart Sociometry
1. I am willing to use the CU Smart Sociometry.
2. I acknowledge the significance of using the CU Smart Sociometry.
3. I am enthusiastic to learn how to use the CU Smart Sociometry.
4. I am willing to help my peers with the use of the CU Smart Sociometry when they encounter problems while using the web application.
5. I think that the CU Smart Sociometry has been appropriately designed in areas such as images, fonts, colors, icons, buttons, and hyperlinks.
6. It is worth using the CU Smart Sociometry.
7. I can learn how to use the CU Smart Sociometry on my own by reading the manual.
8. I can use the CU Smart Sociometry according to my requirements.
9. When encountering problems while using the CU Smart Sociometry, I can seek solutions on my own.
10. The CU Smart Sociometry was designed to be user-friendly and convenient.
11. I am satisfied with the use of the CU Smart Sociometry.
12. I can communicate my experience regarding the use of the CU Smart Sociometry to my peers.

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