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Co-Reflective System: Supporting Collaborative Critical Thinking and Knowledge Building

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***Abstract*—**Service-learning pedagogy provides practical learning experience for students by integrating community service with academic learning. However, experience is not enough, reflection on that experience is essential to produce new understanding. The concept of collaborative reflection has been recognized recently however, there is lack of research on how to structure guided collaborative reflection to view the process of knowledge building and how technologies can support it. To shed light on this issue, this study proposed a computational workflow of structured collaborative reflection which is adopted from integrated collaborative reflection model and implement a prototype (i.e. named as 'Co-Reflective') to proof the concept how Computer Supported Collaborative Reflection System (CSCRS) is supporting collaborative critical thinking and knowledge building. For this purpose, design science research methodology was employed in this study. The evaluation of Co-Reflective is provided where we asked our participants to evaluate their experience and give feedback about system. Based on the positive feedback of participants we conclude that Co-Reflective can effectively support for guided collaborative reflection activities to promote collaborative critical thinking and knowledge building. Implementation of Co-Reflective not only addresses the limitations of current technologies but also contribute in the body of knowledge by presenting the concept of integrated collaborative reflection model that promotes collaborative critical thinking and knowledge building.

***Keywords*—**collaborative knowledge building, collaborative reflection, Computer Supported Collaborative Reflection System (CSCRS), service learning.

I. INTRODUCTION

Traditional education system has been incorporated service-learning approach in their curriculum that provides experiential learning environment for students. Where curriculum was redesigned to integrate community service with academic learning. There are three important components of service learning such as reciprocal learning, community service and reflection on service experience that differentiate it from other types of experiential learning (i.e. volunteerism, internship). Reflection on service experience produce key concept of learning from experience as [1] suggested that "reflection turns service experience into learning". Reflective learning practice is vital for developing critical thinking abilities among students and producing new understanding from service experience.

Reflection is the multifaceted concept and it is not only used for academic learning but also used for professional learning on workplace [2]. There are two ways to conduct reflection i.e. individual and collaborative. Most of scholars' considered reflection as an individual cognitive learning process for personal growth however, current studies (e.g. [3], [4], [5], [6] described the concept of collaborative reflection with reference to professional learning on the workplace. Previous studies informed that collaborative reflection practice for service-learning experience is less documented specifically, current service-learning reflection models focused on individual reflection only. Furthermore, another gap identified in the literature is the lack of proper tool support for guided collaborative reflection. Most of the current tools provide support for individual reflection only however, some tools with limited functionalities can be used for collaborative or group reflection for example discussion forum (see next section for further elaboration).

The main objective of this study is to introduce the computational workflow for structured collaborative reflection which is based on the concept of integrated collaborative reflection model. We describe the concept of integrated collaborative reflection and implement a computer supported collaborative reflection system (CSCRS) as proof of this concept. This study contribution includes: 1) a computational workflow for structured collaborative reflection that uses the concept of integrated collaborative reflection model, 2) Implementing a user friendly computer supported collaborative reflection system (i.e. Co-Reflective) that aims to support collaborative critical thinking and knowledge building, and 3) applying computer supported collaborative reflection system in service learning that encourages greater students

interaction in reflective learning activities.

In this article we first provide the review of related work and research methodology adopted for this study. In section 4, we introduce the integrated collaborative reflection approach, a computational workflow for structured collaborative reflection and its implementation into a system along with overall system architecture. Next, section 5 provide the user interfaces of the system. Then, we explain how we employ system (Co-Reflective) in a service-learning class to support collaborative reflective learning and knowledge building in section 6. Furthermore, in section 7 we discuss the evaluation of Co-Reflective. Finally, section 8 presents the conclusion of this study and possible future work directions.

II. RELATED WORK

2.1.What is Reflection?

The term 'reflection' is widely used in academic learning and much studied by scholars to explain the purpose and process of reflection. [7] define reflection as "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends". In this study, we will discuss further reflection with the reference of service learning that is the type of experiential learning. Particularly in-service learning reflection defines as deep and critical thinking about service experience [8]. [1] defined reflection as the process of re-evaluating service experience and transforming critical thinking into applicable knowledge. In the context of experiential learning reflection plays vital role in evaluating what has been learned during practical learning and think back to produce new knowledge from service experience [9].

Reflection is an important component of service learning and used as purposeful activity to promote critical thinking. In this regard, most of the service-learning scholars (e.g. [10], [11], [12]) reported that reflection is used to assess student's learning from service experience. In order to support reflection as a purposeful activity [13] stated that reflection is not only a thinking process, it includes internal mental processing with intended purposes or outcomes for solving unstructured problems. The importance of reflection in service learning is also defined as reflection on service experience that helps to gain deeper understanding of course contents that learnt in the classroom [14]. In some recent studies researchers (e.g. [15], [16], [5]) argued that reflection is not only individual cognitive process it can be collaborative critical thinking process where two or more learner engaged to re-evaluate their experiences.

2.2.Collaborative Reflection and its Characteristics

Numerous scholars (e.g. [17], [18], [19], [20]) acknowledged that reflection has theoretical roots in Dewey's theory of reflection however, he considered reflection as individual cognitive learning process. [21] claimed that [7] missed the idea of 'affective learning' which was recognized by [1] who considered reflection as purposeful activity that includes both cognitive and affective learning in a unified way. However, reflection theory of [1] supports professional learning at workplace by defining reflection-in-action and reflection-on-action.

In this regard, [6] proposed the concept of collaborative reflection which was based on [1] reflection theory. He defined collaborative reflection as "a collaborative critical thinking process involving cognitive and affective interactions between two or more individuals who explore their experiences in order to reach new intersubjective understanding and appreciations". In addition to this, [4] have suggested a collaborative reflection blueprint that support collaborative reflection at workplace and emphasized on documentation of information during work which later used for individual or collaborative reflection. Moreover, [4] argued that [6] mainly focused on affective learning domain, communication and relationship building.

In addition to this both [6] and [4] have suggested collaborative reflection at workplace and less attention has been given to the outcomes and the process of co-construction of knowledge during collaborative reflection activity. A recent study by [22] described that the nature of collaborative reflection is different than individual reflection in a way the process is take place. It has unique characteristics that engaged two or more learners in dialogical interaction to share mutual experiences to produce new understanding. They also stated that reflection in service learning has intended objectives to train students to develop critical thinking skills, critically evaluate the application of knowledge learned in the classroom and construction of new knowledge.

As discussed above reflection in service learning is about re-evaluating service experience to produce new understanding of course contents or develop new knowledge from this experience. However, most of the current reflection models focused on individual reflection. Therefore, one of the parts of our ongoing research project was modifying current collaborative reflection model to structure collaborative reflection activities for student in service-learning courses. Further detail of collaborative reflection approach and

computational workflow for implementing this approach into a system is discusses in Co-reflective design section.

2.3. Technology Support for Collaborative Reflection

Literature provides evidence of technology use for reflection mainly for data capturing and maintaining records which later used for reflection [23], [24], [25], [4]. [26] have suggested that technology support for reflection can be designed by process display, models, prompts and social discourse. In literature we found the usage of technology for individual reflection such as: web 2.0 applications [27], mobile applications [28], personal online diaries and journals [29], [30]. Most of these tools are used to note experience and capture experience related data that further used for reflection [4]. Some scholars [31], [32], [33] have reported the use of electronic portfolios which is also used for maintaining learning material, personal notes to reflect on learning process. In addition to this Microsoft SenseCam is another tool that can be used for reflection that help to record experience in form of pictures and later used this data for reflection [23].

As [4] have suggested that current tools can be effective for individual reflection. Moreover, they argued that data capturing and maintaining record of experience is vital to perform collaborative reflection on workplace, as human memory is limited and memories getting fade with the passage of time. Therefore, they developed a mobile application named 'Talk Reflection' for data capturing and self-assessment on the workplace (in hospitals) [4]. This application provides some functionalities mainly focused on documentation of events during cases at the workplace which can be later used for reflection. It also provides open discussion environment where users can share their own experiences with others. The findings of this study showed the 'Talk Reflection' application is good for documenting conversations and feelings on the spot that can be further used in collaboration. However, the approach provided by [4], is more appropriate for the professional reflective learning at the workplace and reflection-in-action.

Based on the above discussion, we conclude that majority of current tools provide limited functionalities such as: data capturing and maintaining records that later used for reflection and those tools can be effective for individual reflection. However, in context of collaborative reflection in service-learning experience where collaboration of many students is required to document their personal and collaborative thoughts, scaffolding student interaction to foster collaborative knowledge building from learning experience. As some scholars (e.g. [10], [34], [12]) reported that reflection can be used as assessment tool to assess students learning from service experience. Moreover, reflection is complex activity as reported by scholars' therefore proper scaffolding is required to guide students during collaborative reflection [5].

To the best of our knowledge very few tools (like Talk Reflection application) available for collaborative reflection particularly there is no proper tool that provide support for effective communication and collaboration, proper documentation of individual and collaborative thoughts, promising time to time reflection, scaffolding for guided collaborative reflection activities, supporting students collaborative critical thinking and knowledge building. Additionally, this article presents the next part of research which is design and develop a technology support for collaborative reflection by utilizing the proposed integrated collaborative reflection approach (see next section).

III. METHODOLOGY

The design science research methodology is adopted for the research setting of this study. As it is more suitable for solving identified problem by designing, developing and evaluating IT artefact in the domain of IS research. According to [35], there are six steps in design science research methodology that was employed in this search:

3.1.Problem Identification and Motivation

The problem identified above motivates us how to design and develop an innovative computer supported collaborative reflection system that aims to support collaborative critical thinking and knowledge building after a group service-learning experience. The critical review of current studies revealed that existing ICT's are unable to support guided collaborative reflection. In this context, service-learning practitioners and academicians are looking for technological solution to conduct guided collaborative reflection that aids for collaborative critical thinking and knowledge building.

3.2.Define the Objectives for a Solution

The objective of this study is to design and develop an innovative IT artefact (prototype system) for guided collaborative reflection that aids collaborative critical thinking and knowledge building in an online collaborative learning environment. For this purpose, we have utilized the integrated collaborative approach to design our system, Fig. 1 presents the computational flow for this approach.

3.3.Design and Development

The design of collaborative reflection system is well founded on integrated collaborative reflection model that provides a structure or step by step procedure how to conduct collaborative reflection. Moreover, the development or implementation of system followed the current software development methods such as: prototyping method and system development process that consists of multiple generic phases to implement a system [36].

3.4.Demonstration and Evaluation

[35] considered demonstration and evaluation phase separately however in this study we have combined both phases as some scholars argued that demonstration is initial evaluation to test a system with target users. In this regard the CSCRS was tested in one service-learning course for collaborative reflection activities to validate the usability and effectiveness of system for intended purpose for which it was developed.

3.5.Communication

The design and development process of collaborative reflection system is planning to share with scientific community by publishing research in conferences and journals.

3.6.Co-reflective Design

a. *Concept of Integrated Collaborative Reflection Model (ICRM)*

As discussed above reflection is an important component and traditionally reflection is per-formed individually. This method is not effective option with the large number of students, and with the group-based service-learning projects. It could be possible students might not want to participate in individual reflection activity because of short time frame. Moreover, it might not be convenient for instructor as well to assess students collaborative reflective learning from group-based community service projects.

Practically, when integrating experiential learning (i.e. service learning) with traditional classrooms it could be very hard for students to manage reflection activities with lectures and service projects together within a limited time period. This article presents the computational workflow for structured collaborative reflection which is adopted from integrated collaborative reflection model and implement a technology support for it. In this section we define the concept of integrated collaborative reflection model. There are two main characteristics of integrated collaborative reflection model such as: 1) providing a process of collaborative reflection which includes five stages: group experience, individual reflection, collaborative reflection, recommendation and decision & outcomes and 2) presenting a process of knowledge building during these stages that also comprises of sub-processes i.e. internalization, externalization, conceptualization, negotiation and integration & collaborative knowledge construction. Throughout the development of Co-Reflective we have considered these characteristics.

Fig. 1 presents the computational workflow of structured collaborative reflection in Co-Reflective which is adopted from integrated collaborative reflection model. The process begins when course instructor creates reflection prompt questions and collaborative reflection quiz using these questions. For this purpose, system provides reflection preparation module which helps to create reflection prompt questions and structure them according to different levels of bloom's taxonomy. After preparation of collaborative reflection test instructor send this test to the particular group of students who registered in the system by participating in a service-learning project through project creation module of this system. Our system sends notifications to all students.

Then students add their individual reflection (response) according to reflection prompt questions from their web-based interface and click ready to discuss button. Once all students (in a group) submitted their individual response and click ready to discuss button, system integrates all students' individual reflection and present them into an integrated window for collaborative reflection. This is the second stage according to the integrated collaborative reflection model in which sharing of individual reflection or personal thoughts with others triggers collaborative reflection. The purpose of using reflection prompt question (which is based on revised Bloom's taxonomy) is to trigger individual reflection and scaffold further discussion in collaborative reflection.

Once system shows the integrated view of all responses to entire group, group members can read, rate and comment on other's individual reflection, for in depth analysis of group service experience. Then students' starts discussion to reflect on their service experience, present personal recommendations and negotiation on different point of views in order to reached on shared understanding. This is recursive reflection process until all group members' shows agreement to achieve collective knowledge by refining different ideas. The collaborative reflection process is

entirely student centric where students develop collaborative critical thinking and co-construction of knowledge.

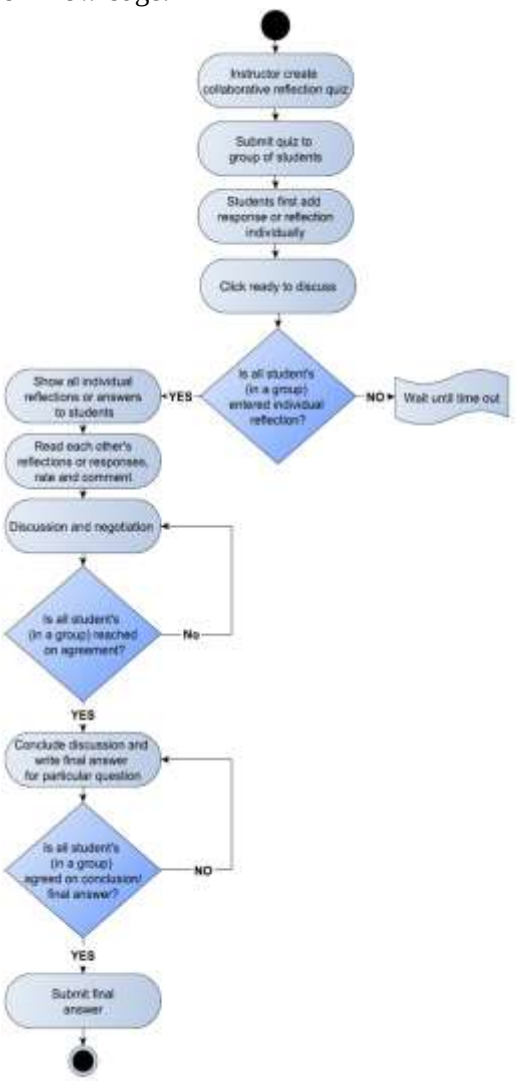

Fig. 1 Computational Workflow of Structured Collaborative Reflection (Adopted from Integrated Collaborative Reflection Model)

However, at the time of project allocation (through project creation module) to students' instructor assign a group leader who will be responsible to lead all interaction during collaborative reflection as described above. The group leader of the project is responsible to conclude the whole discussion by writing the final answer and asked their group members for second opinion to co-construct knowledge. Once all group members agree on conclusion of discussion (final answer) group leader will submit the whole quiz (which includes, students' individual reflection, collaborative discussion and final collaborative knowledge) to instructor. In this process there are some other situations when some students (group member) unable to participate in discussion. Thus, system sends the notification and implement dead line to finish this task. The Co-reflective mainly design to conduct structured collaborative reflection that promotes collaborative critical thinking and knowledge building. This system can be used in classrooms as well to engaged students in collaborative reflection about different course concepts and theories.

b. Design of the Co-Reflective (a computer supported collaborative reflection system)

In order to provide technology support for collaborative reflective learning, system includes threefold collaborative reflection environments one of them is structured collaborative reflection module which is designed to proof the concept of integrated collaborative reflection model as computational workflow is discussed above. Another module is teacher/student-initiated reflection which provides inter-group communication environment for students which is monitored by course instructor. However, this module is unstructured, where students and teacher can share personal experience or project related material that allows other group members to reflect on it. In addition to this system also provides a self-regulated reflection module that servers for two purposes; firstly, it allows students to update their daily service-learning project progress and reflect on it collaboratively; secondly, it allows course instructor to monitor student progress by following student's daily activities and reflection learning. This module is very effective to monitor student progress as they are working on remote places.

Moreover, system also offer a separate individual reflection module to measure student attitude and behavior towards service-learning project. In the current version of system result visualization module only generate automatic results for individual reflection and presents in appropriate format. In implementation section we describe how this system will help students to reflect collaboratively to develop collaborative critical thinking and knowledge building skills. The design of Co-Reflective provides a secured inter-group net-worked platform that enables real time interactions and ensure continues time to time reflection. Moreover, the appealing characteristic of Co-Reflective is it provides a conducive medium for structured collaborative reflection that ensures the level of privacy required for fostering collaborative critical thinking and knowledge building among students. There are seven system modules in the design of CSCRS: Project creation, reflection preparation, structured collaborative reflection, individual reflection, teacher/student-

initiated reflection, self-regulated reflection to update project progress and result visualization and reporting module. The overall picture of system architecture is presented in Fig. 2.

The Architecture of system consists of three layers: 1) presentation layer, 2) business (process) layer, and 3) data storage layer. The layered architecture technique is widely used for dividing complex system development task into manageable parts. Furthermore, each layer in the system architecture designed to perform specific functions which is logically related with the concept of integrated collaborative reflection approach. For instance, the core module (structured collaborative reflection) presents implementation of proposed integrated collaborative reflection model however, other system modules are important to achieve intended objectives. The Co-Reflective is implemented using entirely open source tools such as: Laravel and Bootstrap (PHP web development frameworks), SQL server and high-level languages PHP, Javascript and Html.

In addition, the data storage layer is responsible for storing data used in the functions of the business layer of prototype. The business (process) layer of the system contains core functions or main logic of the system and deals with the implementation of important system modules as presented in Fig. 2. The presentation layer contains the graphical user interface and presents system functionalities from business layer to users. This layer also works as bridge between users and system and mange user's interaction with system.

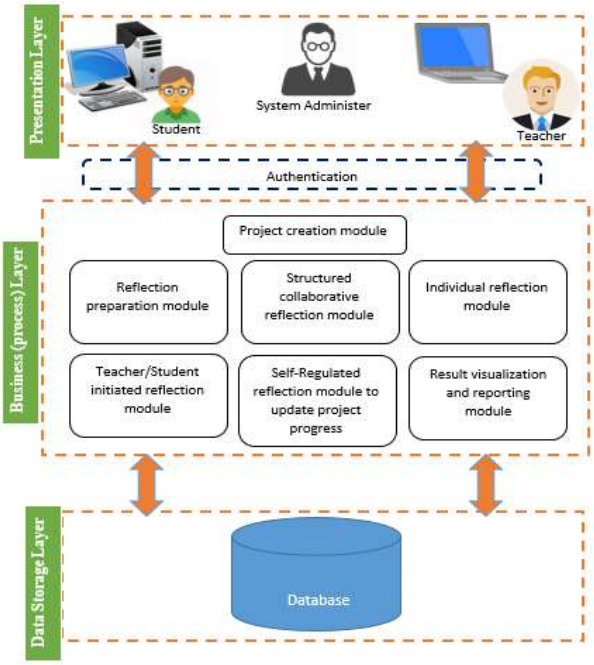

Fig. 2 Co-Reflective architecture

3.7.User Interface of Co-Reflective System

As described in previous section the Co-Reflective system consists of seven modules. Among these modules structured collaborative reflection module is core module which provides a computational workflow (i.e presented in Fig. 1) for conducting a guided collaborative reflection. However other modules such as: project creation, reflection preparation, self-regulated reflection module and interaction support it by providing a comprehensive collaborative reflective learning environment. This section presents the user interface of web based system (i.e. Co-Reflective) which shows how system provides support for guided collaborative reflection to promote collaborative critical thinking and knowledge building.

In this paper we describe some of modules (e.g. project creation and reflection preparation) of this system which are directly related to core module (i.e. structured collaborative reflection). Fig. 3 shows the "project creation module" which includes all functionalities required for project creation (on instructor side 3(a)) and project selection (on student side 3(b)).

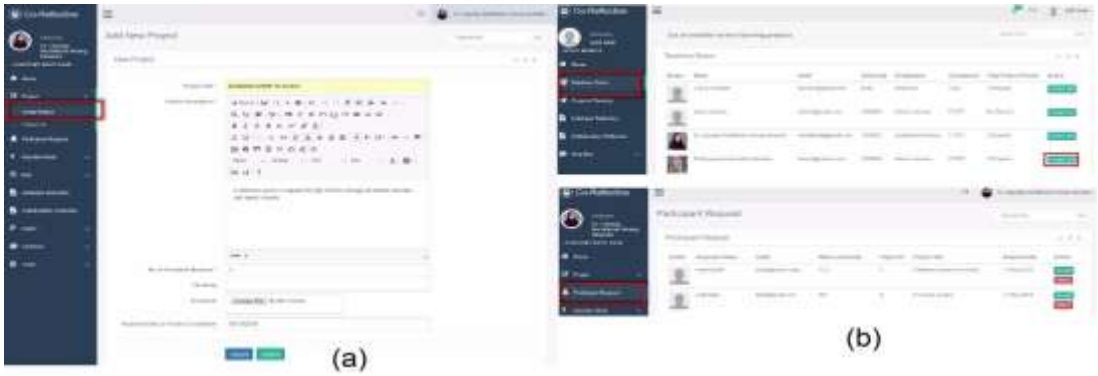

Fig. 3 User interface for project creation module

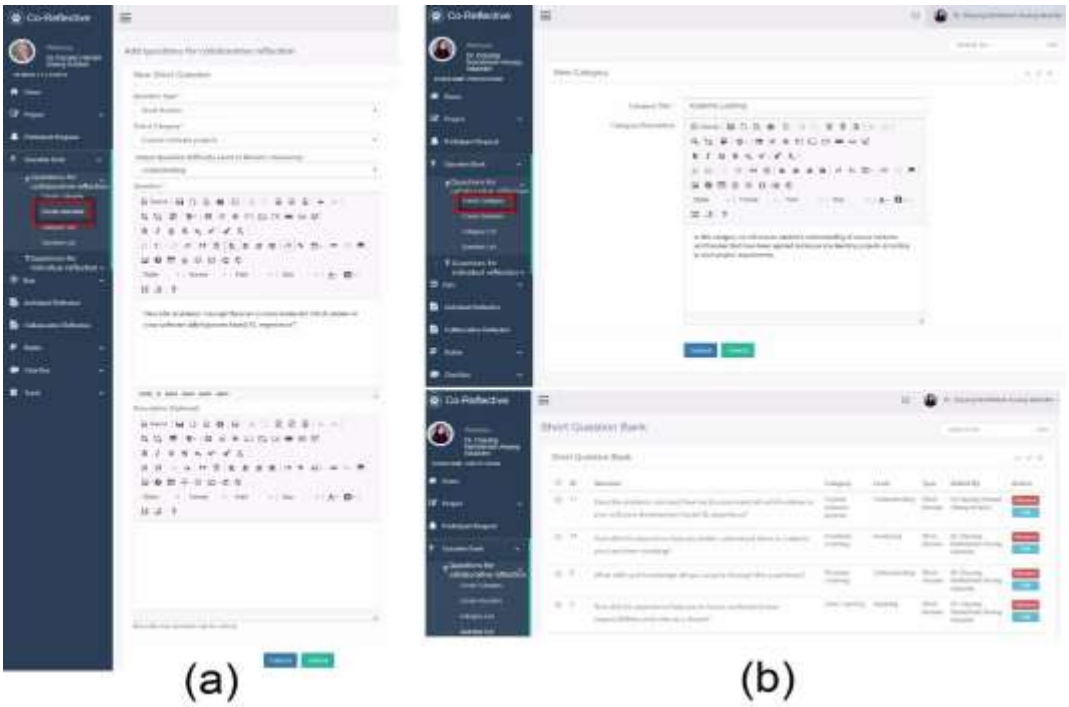

Fig. 4 User interface for project creation module

Moreover, Fig. 4 presents the "*reflection preparation module*" which allows to create shared quiz bank where instructor can create reflection prompt questions, reflection quiz and maintain the lists of current reflection prompt questions that other instructors can also use to obtain the desired objective of collaborative reflection activity. It is important to note here system organized reflection prompt questions which were designed by using the revised Bloom's Taxonomy [37] that facilitates to achieve high level of critical thinking. It provides a structure that helps students to move from descriptive to more critical thinking level, along with this it also helps instructors to assess collaborative reflective learning on different levels.

The core module (i.e. structured collaborative reflection module) of system contains five pages: instructor can create and assign collaborative reflection quiz (which is created with help of reflection preparation module) to specific group of students (see Fig. 5).

Fig. 6 presents the individual reflection page where student can add their personal understanding based on service experience without any help, here reflection prompt questions trigger individual reflection based on his/her personal experience and prior knowledge. Here student utilize the all information collected from service experience then he can click ready to discuss button which shows student is ready to share his/her point of view with other group members (this is similar to the wave hand function in traditional classroom). At this movement system sends notification to all students to inform them and call for participation in collaborative reflection.

Additionally, Fig. 7 presents the third page for structured collaborative reflection module, where system presents an integrated view of all students' individual reflection that provides collaborative

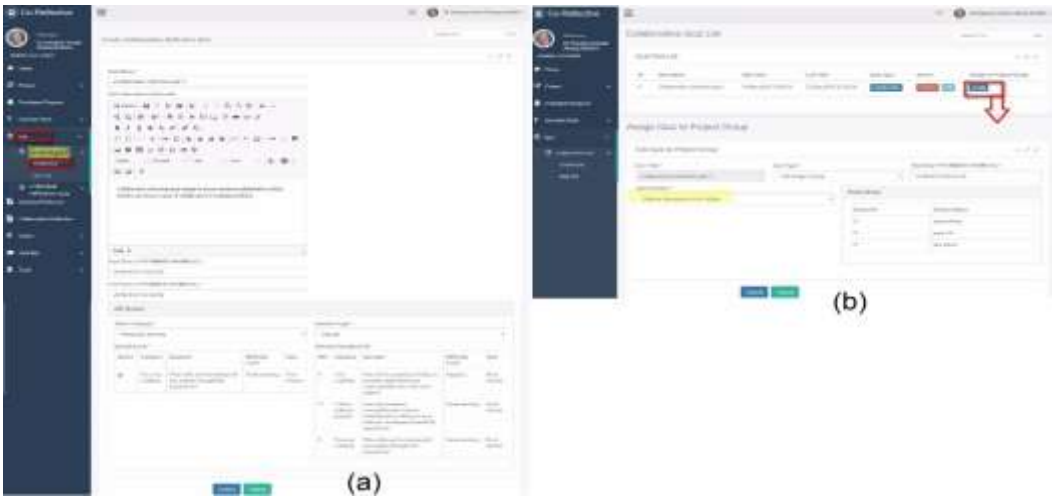

Fig. 5 User interface to create and assign collaborative reflection quiz

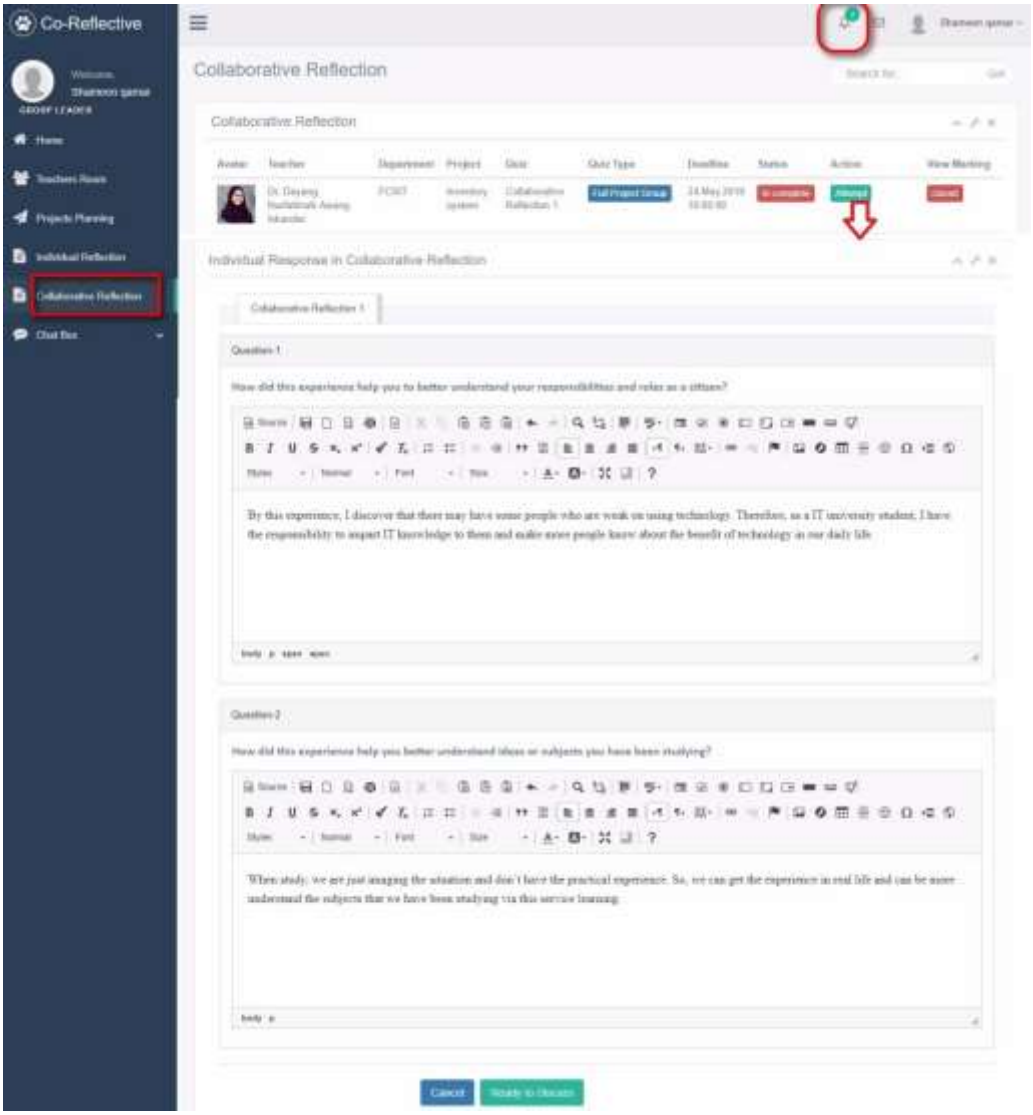

Fig. 6 User interface to add individual reflection page

learning environment where entire group of students can read, rate and comment on others response. Comment page is separated to ask student to give reference for comment for instance scaffold comments as based on theory or personal opinion/experience. The collaborative reflection

begins here when system allows students to collaborate with their group members and produce collaborative critical thinking.

An additional discussion page is presented in Fig. 8, that provide a place where student can discuss, negotiate on different point of views and elicit collaborative critical thinking and knowledge. Fig. 9 is presents the final answer page, where group leader can draw conclusions on collaborative reflection and ask their group members for second opinion, it presents a recursive reflection. Students can use the discussion page to give their comment on final answer, when all group members are agreeing on one point, group leader sends whole collaborative reflection quiz (which includes individual and collaborative reflection with final shared understanding) to instructor. This module is implemented according to the computational workflow of structured collaborative reflection to proof the concept of integrated collaborative reflection model Is discussed above.

IV. IMPLEMENTATION OF CO-REFLECTIVE: A CASE STUDY

In this section we present a case study and explain how we implemented Co-Reflective in a service-learning course to support collaborative reflection and co-construction of knowledge. As discussed earlier, the concept of integrated collaborative reflection model is implemented into a Co-Reflection system to achieve collaborative critical thinking and knowledge building. In addition to this we also explain how we achieved collaborative critical thinking by utilizing the structure of Bloom's revised taxonomy [37] and how knowledge building theory [38], [39], facilitate the co-construction of knowledge in collaborative reflection activity.

The main objective of Co-Reflective system is to encourage more collaborative critical thinking activities and help learners to develop intellectual critical thinking and knowledge building skills. In this experiment we selected a service-learning course named "Technopreneurship and Product Development (TMC3034)", in which the course instructor allocated service-learning projects to students in one semester. A workshop was conducted to demonstrate the usability of system for collaborative reflection activities with the under-graduate students of service-learning course (i.e. Technopreneurship and Product Development (TMC3034)) at Universiti Malaysia Sarawak. The purpose of this workshop was to evaluate the usability and effectiveness of Co-Reflective system for guided collaborative reflection for which it was developed. We asked students and Service-Learning team members to voluntarily participate in this workshop to evaluate our Co-Reflective system.

We begin our workshop with the introduction of collaborative reflection and the revision of some important concepts (such as service, reflection learning) of service-learning projects that taught in service-learning course. After that collaborative reflection tasks were designed according to the requirements of Service-Learning projects by using reflection prompt questions. Thus, we distribute a softcopy of system user manual for participant's help during collaborative reflection task as well as we also explain rules and overall collaborative reflection process through a brief presentation.

Next, we submitted the prepared collaborative reflection task to the participants of the workshop who divided into the 16 groups (according to the 16 different service-learning projects), including 3-5 members in each group. The service-learning projects was created, and students were allocated for each project by using project creation module of the system. Once, all participants received collaborative reflection quiz they start individual reflection by utilizing personal understanding from service experience. In the cognitive domain, this process covers the 'understanding' level of revised Bloom's taxonomy [37] and students also go through the 'internalization' process according to the integrated collaborative reflection model, by internalizing the all prior information obtained from service experience/classroom and process this information in their cognitive system to individually reflect on service experience [40]. The reflection prompt questions help students to trigger individual critical thinking process to expand their individual knowledge. This also encourages students to critically think about personal understanding of service experience and compare with previous knowledge in order to reflect, presents knowledge in explicit form.

Sometimes later, when all group members in a group click the 'ready to discuss' button, system will integrate all responses to show into integrated window and share with entire group for collaborative reflection (as this stage discussed in ICRM). In this step student will read, rate and comment on others individual reflection by applying prior knowledge learned from service experience / course content learned in classroom. As a result, they able to elicits different point of views or knowledge and express them in appropriate way to reflect on service experience. At this stage students cover the next level of cognitive learning process (apply) and knowledge building theory (externalization) by externalize their

own knowledge to other group members of their service-learning project [40], [37].

Fig. 7 User interface to add individual reflection page

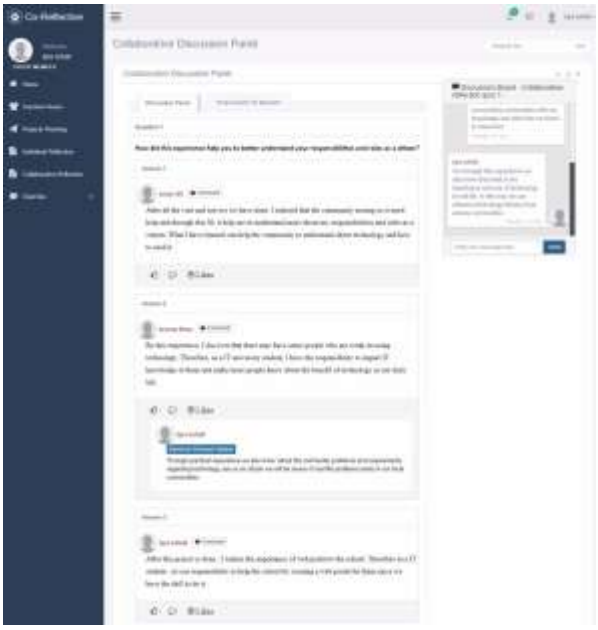

Fig. 8 Screenshot of discussion page

In addition, with range of point of views students initiate discussions and negotiation to critically analyze and evaluate information in the light of group service-learning experience. They critically analyze the application of course contents and theories in real world service-learning experience to produce new knowledge. This process confirms students developed collaborative critical thinking skills which covers the fourth and fifth (analyze & evaluate) level from revised Bloom's taxonomy. Furthermore, with reference to the knowledge building theory [38] through 'recommendations & negotiation' process students move to the shared understanding by interacting with each other's.

According to, the integrated collaborative reflection model, students' needs to conclude discussion in order to reach an agreement. We asked the group leader of the project to leads your group members and draw conclusion on discussion. In the 'final answer' page, group leader can write the conclusion of discussion for each reflection prompt question. Then he will share again with their group members for their opinion, here they repeat negotiation process until they interactively achieved

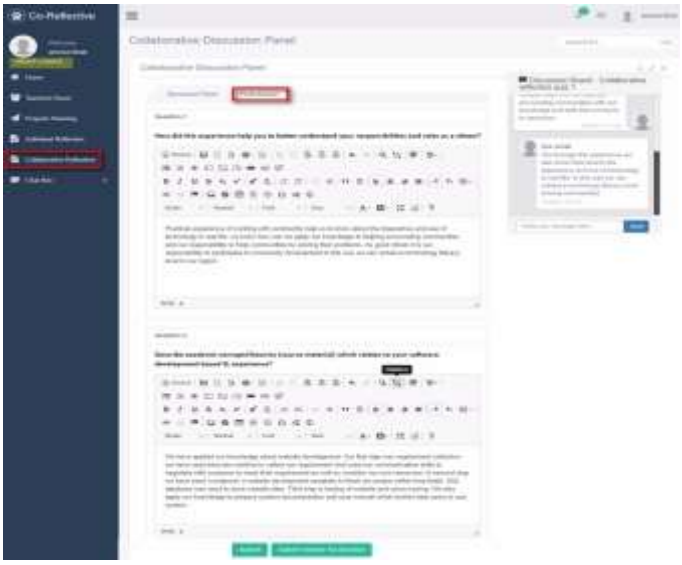

Fig. 9 Screenshot of final answer (drawing conclusion for co-construction of knowledge)

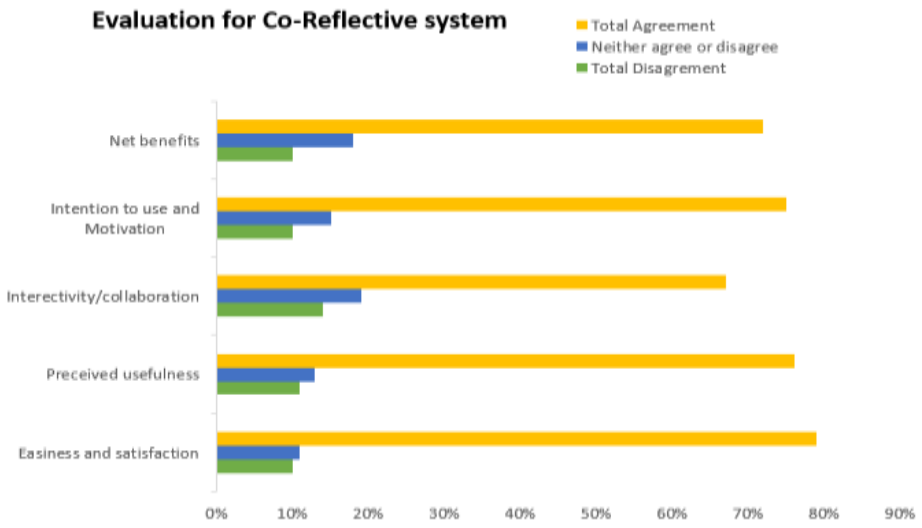

Fig. 10 Overall Rating of CSCRS

collaborative knowledge. Here system support to manage/store each iteration process to view refinement of ideas to build knowledge. As a result, students create new knowledge, thus covering the critical level (create) of revised Bloom's taxonomy. Furthermore, collaborative knowledge building takes place by integrating knowledge that is constructed at group cogitation level as proposed in integrated collaborative reflection model. According to [38], [39] the knowledge constructed at group level may not be in individual minds, however it may be interactively co-constructed in group discourse.

V. EVALUATION

This section presents the evaluation of Co-Reflective system, we asked workshop participants to voluntarily participate in a survey. The survey was distributed to all participants' and feedback was collected at the end of workshop. The survey consists of several questions that evaluates the systems' 'perceived usefulness' and 'net benefits' for intended purpose for which it was developed, students' overall collaborative learning through 'level of interaction', level of learning interest (which shows intention to use Co-Reflective system in future) and motivation, and overall users' satisfaction with system performance. A seven-point Likert scale ranged as "strongly agree to strongly disagree" was used to record users' level of agreement for all survey questions. Total 80 survey responses were collected; Table 1 shows the fifteen survey questions along with statistics attained from the respondents.

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TABLE 1
OVERVIEW OF SURVEY RESPONSES

Seven-point Likert type scale 1= strongly disagree, to 7=Strongly agree			
Questions	Strongly disagree/ Disagree / somewhat disagree	Neither agree or disagree	somewhat agree/ agree / strongly agree
The Co-Reflective (CSCRS) system is easy to use	10%	10%	80%
The CSCRS makes the collaborative reflection task enjoyable	10%	12%	78%
Overall, I am satisfied with the performance of the system	10%	10%	80%
CSCRS provides comprehensive information which I exactly want for reflective learning	20%	12%	68%
The CSCRS provides flexible and interactive features between user and system.	10%	18%	72%
The functionalities of CSCRS were very useful for collaborative reflective learning.	4%	8%	88%
Using CSCRS to interact with others creates a personal environment for communication.	24%	16%	60%
I felt comfortable participating in the collaborative discussions through CSCRS.	16%	24%	60%
The CSCRS enhanced interaction between me, peers and teachers.	2%	18%	80%
I will keep using CSCRS for future reflective learning.	6%	22%	72%
I intend to use CSCRS on regular basis to improve my critical thinking skills and collaborative learning	10%	8%	82%
I will recommend CSCRS to my friends for future reflection practices.	14%	16%	70%
The CSCRS helps me to improve my performance in collaborative reflective learning	8%	14%	78%
Using CSCRS promotes critical thinking skills and collaborative knowledge building.	6%	22%	72%
Using CSCRS helps me to make connection between informal (i.e. learning at community service site) and formal (i.e. learning in classrooms) learning experience.	16%	18%	66%

The results show participants' positive attitudes to the use of CSCRS for collaborative reflection activities to produce collaborative critical thinking and knowledge. The survey shows high results (80%) for our system's ease of use and user satisfaction. Moreover, most of the surveyed agree the collaborative learning environment in Co-Reflective system makes collaborative reflection task more interesting (78%) and helps students to develop critical thinking skills and collaborative knowledge (72%). Furthermore, 78% of those surveyed consider that system increases their performance in collaborative reflective learning and that system provides useful functionalities which is required for collaborative reflective learning (88%).

Additionally, about 60% of the surveyed believe that inter-group discussion makes the reflection task interesting and Co-Reflective system enhances interaction between them, peers and teachers (80%). Around 60% system users also believe that they feel comfortable to participate in collaborative reflection and 68% appreciate the comprehensive information provided by Co-Reflective system for students' guidance which is exactly required for collaborative reflection task. Furthermore, more than 70% agree that Co-Reflective system features are flexible and interactive, and they plan to use Co-Reflective on regular basis to improve their critical thinking skills (82%).

Moreover, about 66% of those surveyed found system effective to make connection between informal (learning during service) and formal (learning in class room) learning experience. Lastly, among those surveyed 72% would like to use Co-Reflective system for their future collaborative reflection practice and 70% would recommend it to others. Based on the above results we plan to study possible reasons that can be helpful to motivate students' collaborative reflective learning. More importantly, we found slightly low agreement on system interactivity and net benefits as compare to others therefore we plan to modify our system in the near future.

Fig. 10 illustrates the overall ratings of Co-Reflective system. In order to provide accumulative results in Fig. 10, we combined fifteen survey questions (from Table 1) into five categories: 1) net benefits, 2) intention to use and motivation, 3) interactivity and collaboration, 4) perceived usefulness and 5) easiness and satisfaction. In the following chart, we notice that more than 65% of those surveyed agree that Co-Reflective system helps them: 1) to enhance performance in collaborative reflective learning and develop critical thinking skills, collaborative knowledge (net benefits) 2) build interest and motivation to use Co-Reflective system (intention to use and motivation) 3) increase interactivity and collaboration between participants, 4) improve collaborative reflective learning and knowledge by providing effective features which shows Co-Reflective system usefulness for collaborative reflection tasks (perceived usefulness)

and 5) increase the level of easiness and use satisfaction.

The findings of system evaluation further confirmed that Co-Reflective system (a computer supported collaborative reflection system) can facilitate service-learning students' collaborative reflective learning and knowledge building better than traditional methods used for collaborative reflection (i.e. group discussion). Specifically, guided collaborative reflection approach offer a structural framework to conduct collaborative reflection with guidance and document whole process (e.g. every step of collaborative reflective learning). Moreover, the positive feedback of students shows that Co-Reflective system is enjoyable and most of them are satisfied with how system used in service-learning course for collaborative reflection activities.

Furthermore, students believe that Co-Reflective system provides effective collaborative learning environment which enhance peer interaction, motivates students to participate in collaborative reflective learning, helps them to enhance collaborative critical thinking skills and understanding of connection between informal (learning during service) and formal (learning in class rooms) learning experience. Lastly, most of the participants satisfied with collaborative knowledge building that take place during collaborative reflection activity.

VI. Conclusion and Future Work Direction

In this study, we have presented a computational workflow of structural collaborative reflection, which employs the concept of integrated collaborative reflection model to support collaborative critical thinking and knowledge building. Firstly, the description of integrated collaborative reflection model is presented to define theoretical concept behind proposed system. Then, the detail implementation of Co-Reflective (i.e. computer supported collaborative system) is provided that includes seven modules to conduct guided collaborative reflection by providing a collaborative learning environment.

Then, we explained the demonstration and evaluation of Co-Reflective system in service-learning course to promote collaborative critical thinking and knowledge building skills among students. In addition, we also discussed how we can achieve collaborative higher-order critical thinking (based on revised Bloom's taxonomy) and knowledge building (based on knowledge building theory) by using Co-Reflective system which facilitates students to develop collaborative critical thinking and co-construction of knowledge. Finally, evaluation results system showed positive feedback of participants and confirms Co-Reflective system can support collaborative reflection and co-construction of knowledge. In future, we plan to use Co-Reflective system in more service-learning courses for collaborative reflection activities and evaluate it with more users for its usability and effectiveness. In addition, we also plan to adapt IS success theory to validate Co-Reflective system by identifying and measuring its success factors. We also plan to improve system by contributing more functionalities such as: 1) analytical and assessment tool to measure students' behavior and learning during collaborative reflection.

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