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ASSESSMENT OF LEARNING AND THINKING SKILLS VIA PROJECT-BASED LEARNING

SUMMARY

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Introduction

Societal changes influence educational institutions, where raise pupils as better citizens, employers and employees. Technological improvements have changed the societies and educational institutions as well. Curricula of the subjects are composed of both theoretical knowledge and such skills to investigate and solve problems in daily life. In the new millennium, all of us could investigate, comprehend, apply, and analyze information instead memorization to achieve in schools and workplaces. Such skills to be successful are named as 21st century skills, or interpersonal skills, etc. are categorized as academic standards, learning skills, thinking skills, ICT skills and life skills. Although renewed curricula are prepared by concerning such skills, sufficient assessment policies still are not applied. This circumstance reduces priorities of these skills and their acquirements (Ananiadou & Claro, 2009).

Project-Based Learning (PBL) helps to teach and assess 21st century skills as well as the courses. Artists and architectures utilized as a learning method centuries ago. Particularly after 1950`s, universities applied PBL in the courses and then it spread out all educational institutions. PBL allows to opportunity to give constructive feedback students and teacher. In addition, PBL benefits from technology in order to track their` works, to save time for both students and teachers and to motivate students as enhancing sorts of resources and presentation methods. Researches indicated that PBL developed and assessed such skills (Capraro, Capraro, & Morgan, 2013; Chang & Lee, 2010; ChanLin, 2008; Larmer, Mergendoller, & Boss, 2015; Meyer & Wurdinger, 2016; Thomas, 2000; Walters & Sirotiak, 2011).

The group product is presented and assessed at the end of PBL. The purpose of the assessment of the product must be determined for high quality assessment since students performed collaboration and communication skills during presentation. One member could be outward and perform outstanding performance ignoring the teammates. However, this does not make sense with respect to collaboration. Anyone could be good presenter but insufficient team player. Indeed, the assessment of the skills should be separated for more constructive feedback despite its difficulty.

Choosing assessment tool is significant as well as choosing assessment method which must depend on the purpose of the assessment. The majority of the studies collected data via questionnaires, interviews and interview forms to reveal the development of the skills. However, actual level of a skill could not conform to the development of the skill. In other words, less improvement does not imply low ability on that skill since the person who already

possesses the skill well, may not improve it more by applying PBL. Rubrics are beneficial assessment tools to guide pupils though the PBL process and aid to prepare quality products. Scales and criteria present standards and pupils comprehend their weaknesses in their products. Besides, grading group product to assess skills with one score could cause ambiguity since all group members usually do not work with equal efficiency and assessing more than one skill requires more than one score.

In collaborative works, another issue is reluctant group members as well as distinguishing the skills and determining the actual skill level. Such students could reduce the efficiency of collaboration. Therefore, teachers should struggle to motive them and/or prevent others from negative effects of social loafing. This study focused on issues of skill assessment since high quality assessment provides learning and acquiring skills which are requirement for raising human being who search, examine, implement, and evaluate.

Keywords: Assessment, Project-Based Learning, Collaboration, Communication, Critical Thinking, Rubric

CHAPTER I THEORITICAL FRAMEWORK

1.1 LEARNING AND THINKING SKILLS

According to "Framework for 21st Century Learning" (2015), collaboration, communication and critical thinking are classified under the category of `Learning and Innovation Skills` with creativity. In this study, such skills are gathered under the title of `Learning and Thinking Skills`.

1.1.1. Collaboration

Collaboration has been used informally as a learning method for many years. After 1980's it has become more popular in education. Nowadays collaboration is regarded as one of 21st Century learning and innovation skills, required for school life and employment.

Collaboration stimulates to develop social skills such as communication, negotiation, decision-making, and problem-solving and foster students` learning, especially for low-achieving students (Smith & MacGregor, 1992). Similarly, Dillenbourg (1999) defines as collaborative learning "a situation in which two or more people learn or attempt to learn something together". He stated that this general definition was inadequate since group size, duration of learning, learning activities and interactions among group members are uncertain. Since there are many variables as he stated. Group size varies from two or three to whole

class. Teamwork can last one month, two month or more and even type of interaction may differ like face-to-face, computer-support or online.

Collaboration in learning process facilitates understanding, increases motivation and develops metacognition (Dillenbourg, 1996; Hennessey, 1999; Turner, 1995; Webb, 1991). Individuals who receive explanations from teammates should learn new information and the understand the subjects. Moreover they should have opportunities to correct their misunderstandings. In learning process the effectiveness of receiving explanations depends on some circumstances such as the timing and relevance of the explanation, the recevier student`s level and needs. Under these conditions peer tutoring has significant role since the explaning student uses vocabulary and expressions that the receiver student can understand. Collaboration improves the receiver students` learning (Webb, 1991). On the other hand, explainers learn as well since they should repeat the topic to explain anothers. This situation tends the explainer students to clarify and rearrange the topic and notice the receiver`s gaps in learning. Therefore, giving explanations should lead to understand better. The explainer must concern the receiver`s conditions such as level and releveance of explanation for the effectiveness of collaboration (Webb, 1991 retrieved from Bargh and Schul, 1980).

Metacognition is regarded as 'knowledge and understanding of your own thinking' and students` discourses expose conflicts and these conflicts can direct students to clarify their understandings and thoughts while collaborating (Hennessey, 1999). In learning sequence, cognitive processes are integrated with metacognitive processes. New acquisitions such as knowledge about the nature of learning task and effective methods for learning are brought by learner`s introspection (Chiş, 2005).

1.1.2. Communication

Communication is an important basic skill for building good relations with others. Balancing speaking and listening is a requirement for healthy communication. Communication is not only verbal form but also non-verbal (body language) and written forms. In recent years, importance of communication has increased because of media and technological tools such as internet, smart phone, television, etc. Effective communication opens new doors in life and could be vital for some occupations.

As human being, we often communicate with others because of various motivations such as getting information, request for help, following tasks, etc. Interactions between/among people base on communication (Burleson, Metts, & Kirch, 2000). In schools and workplaces, working in group may ease the tasks to complete and may provide opportunity for socialization. Being part of a group may broaden people`s perspectives by

exposure of different ideas and personalities and even people change themselves. Diversity of personalities enhances perspectives and allows getting others experiences (Hargie, 2011). Employers seek people, having good communication skills, are required for various jobs. Good communication skills make people one step ahead in business life (Hargie, 2011).

1.1.3. Critical Thinking

Critical thinking is required in life such as in schools, workplaces and at universities. Everyday people encounter similar but complicated issues. The world has been changed fast and people adapt changing situations better via critical thinking ("Framework for 21st Century Learning," n.d.).

In 20th century, Dewey`s studies enlighten educational sciences. Dewey accepts critical thinking as an active process, calling 'reflective thinking', and defined as 'an active, persistent, and careful consideration of a belief or supposed form of knowledge in the light of the grounds which support it and the further conclusions to which it tends' (Knoll, 1997). APA led an investigation for defining, instructing and assessing of critical thinking. 46 experts are from different disciplines such as philosophy, education, and social sciences succeed a consensus definition. In the Delphi Report, critical thinking is defined as 'be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based.' (Facione, 1990).

Education should not focus on only acquiring knowledge from textbooks because of complexity of life. Daily life issues are complicated due to not depend on a single subject. The world and humans` necessities are shaped up by accumulation of information and technological tools. Adapting new circumstances well is realized via critical thinking. Stobaugh (2013) points out the benefits of critical thinking in schools such as increasing students` motivation, scores in the assessments and their levels of readiness for college. Additionally, in daily life, it is essential for making decisions, developing employability, and sustaining democratic governments. Paul and Elder (2007) summarized this fact as stating 'the quality of our life and that of what we produce, make, or build depends precisely on the quality of our thought.'

1.2 ASSESSMENT

According to Black and William (1998), assessment is teacher and student activities to supply information as feedback to modify teaching and learning activities. Airasian and Russell (2008) mention a broad definition which is `a process of collecting, synthesizing, and

interpreting information to aid in decision making.' Harlen (2007) underlines the judgment and achievement and defines assessment as `the process of collecting evidence and making judgments relating to outcomes, such as students` achievement of particular goals of learning or teachers` and others` understanding`.

Assessment methods and tools are important components of learning and can shape up the curricula and learning process. Main assessment tools are written exams, oral exams, reports, and observation forms which are used to measure students` knowledge and performances. Although these tools give an appropriate idea of learning product, they could lack of assessing the learning process of thinking and learning skills. In addition, essays, projects, rubrics, peer and self-evaluation forms are used. Selecting appropriate method among the alternatives is important for quality of assessment (McMillan, 2014). In performance assessments, students use prior knowledge, and their skills to solve real world problems. These assessments integrate what they learn and how they apply their knowledge and skill for problem solving in order to check students' skills (McMillan, 2007).

Learning Process is seemed as linear because of starting with curriculum, following by teaching methods and then applying assessment. However, results and outcomes of assessment affect the curriculum and then teaching methods. The process is drawn as a triangle (Harlen, 2007). Assessment is carried out not only judging students` knowledge and skills, and graduation of school but also giving feedback, improving curriculum, and learning process (Harlen, 2007; McMillan, 2007; Torrance & Pryor, 2001).

Diagnostic, grading, and editing instructions are the major uses. The results of summative assessment serve as grading due to show students` knowledge level, give feedback to students and teachers and motivate them to learn. The results could influence the lesson plans and teacher may modify types of material, teaching and assessment methods, may allocate more or less time for topics, etc. (McMillan, 2014). Besides, the results may cause to make diagnostic decisions such as understanding students` prior knowledge level, their learning difficulties or determining whether they have misconception or not (Popham, 2011).

1.2.1 Assessment of Collaboration

Webb (1995) mentioned four possible purposes of group-based assessments. These purposes are measuring individuals` learning, assessing a student's ability to learn from group activity, assessing productivity and assessing students` collaboration skills, such as negotiation, decision-making and coordination.

Collaboration in different levels and dimensions could be assessed by rubrics as well (6-12 Collaboration Rubric., n.d.; Capraro, Capraro & Morgan, 2013). For online collaboration, the dimensions may change and be classified in terms of the aim such as purpose, quality, quantity, manner (Goodrich, 1997; Swan, Shen, & Hiltz, 2006).

1.2.2 Assessment of Communication

The purposes of assessment vary on the areas since interest of assessment may have simply moved into more specialized. In the literature clinical, counseling and psychological studies are reached as well as educational researches. Standardized scales and questionnaires are used to assess communication. Rubrics are appropriate tools for such performance-based assessments. NCA enlisted significant communication vital attitudes such as the ability to recognize, speaking clearly and expressively, transmitting a message appropriately, listening attentively, presenting ideas in an organizational pattern, selecting appropriateness of medium for communication, giving information and supporting it with examples, etc. Teachers may enhance their rubrics, based on appropriateness of discipline or department. The Competent Speaker is such a rubric which is tested its reliability and validity and is confronted for communication skills, identified by NCA (Morreale, Rubin, & Jones, 1998). Capraro et al. (2013) presents a communication rubric which is appropriate for assessing presentations.

1.2.3 Assessment of Critical Thinking

Critical thinking is assessed in variety of purposes such as informing teachers and schools about students` success, diagnosing their critical thinking level and giving them feedback, motivating students to be better, doing research about critical thinking and providing information for further educational programs which students decide to enter (Ennis, 1993).

Multiple choice tests, multiple choice questions with justification, short essays or case studies, performance tests and rubrics are the major tools to measure critical thinking skills. Size of test takers affects the selection of assessment method as well as test makers` purpose. Such complex methods are hard to apply large groups in spite of better efficiency of the method. Preparing own test is another method, allowing to arrange comprehensiveness of the test for subject-specific assessment and types of items which even could be mixed methods. Multiple-choice test with written justification could be formed. In justification part, defending own responses can gain partial credit despite of choosing wrong option (Ennis, 1993).

Performance assessments take more time in preparation, process and assessment and must devote more time for each part of teaching and assessment. Giving opportunities to deal

with real life cases and increasing students` motivation and inquiry are its advantages (Ennis, 1993). Rubrics are helpful tools to measure performance as guiding students to enhance quality of their work and assist teachers to assess students` works fairly (Popham, 1997). Educational institutions, foundations, and universities prepares and shares critical thinking rubrics ("6-12 Critical Thinking Rubric", n.d.; "Critical Thinking Testing and Assessment", n.d.; "Critical Thinking Rubric", n.d.).

1.3 PROJECT-BASED LEARNING

Defining PBL is not easy due to its structure and flexibility. The definition should reveal its complex structure to answer ill-defined question and integration with everyday life. Blumenfeld et al, (1991) defined as `a comprehensive approach to classroom teaching and learning that is designed to engage students in investigation of authentic problems.` The common points of PBL are inquiry and investigation. Therefore, the inquiry in learning activities develops students` social skills, curriculum and technological content and defined simply special form of inquiry-based learning (Nastu, 2009; Slough & Milam, 2008).

The Buck Institute for Education (BIE) defines as: *`a systematic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process structured around complex, authentic questions and carefully designed products and tasks.`* ("What is Project-Based Learning?", 2016).

Throughout the years, the definition of PBL has changed slightly to obtain more structured and better framed.

1.3.1 Importance of PBL

PBL may solve the problems as motivating and helping students to meet standards and getting better results on tests, and preparing them for life.

Uninteresting and irrelevant materials may cause dropouts and almost half of students responded `classes were not interesting` in high school dropouts' survey. 81 % of the students responded as it should be more real-world learning for the question what might help them stay in school (Larmer, Mergendoller, & Boss, 2015, retrieved from Bridgeland, Dilulio, & Morison, 2006). When students are occupied with meaningful material, they are able to learn better (Capraro, Capraro, & Morgan, 2013).

PBL gives opportunities students who have various capacities and interests to do what they are interested and this differentiation enhances their motivation. Besides, they feel ownership to projects via having choices and this stimulates their motivation as well (Education Technology Division, 2006). projects are composed of several objectives, from

different levels and chapters to solve real life issues and applying these objectives altogether improves students` knowledge and test scores (Larmer, Mergendoller, & Boss, 2015).

Nowadays, books and teachers are not the only source of study since pupils ease to reach sources from the internet which offers the topics in various levels of knowledge. Searching sources on internet and preparing projects should cause interventions such as going off track and not learning what they must learn (Thomas, 2000). On the other hand, the necessity of considering school formal education with other forms of educations is a challenge of contemporary society. Informal education and non-formal education should take a part in learning (Chiş, 2005). At this point, technology may combine formal and informal education and give opportunities students to learn from various resources.

The competencies and personal skills are called, 21st century skills, or interpersonal skills. Students acquire these skills by PBL. During doing projects students communicate, collaborate, think critically and analytically to solve problem. They explain the topics, concepts and their solutions, answer their classmates` questions and must use time efficiently while presenting their project (Larmer, Mergendoller & Boss, 2015). Consequently, the success in life and college acceptance require such skills as well as achievement in school courses.

1.3.2 Teacher`s Role

Teachers` active roles last from the beginning to the end of the process. BIE compiled the teachers` duties in all parts of the projects and named as Project Based Teaching Practices. According to project based teaching practices, teachers adapt a project for their students and plan as permitting students` interests and choices. They use projects to teach learning objectives and plan the project according to the objectives. The project must help students understanding the concepts and subjects. They improve teamwork and open-ended investigation and allow speaking out students` ideas. They not only design project but also guide students when need. Scheduling tasks and assessments is also teachers` duty. They arrange lessons and tools to support students to fulfill project tasks and to complete the projects. They assess students` knowledge and success skills. They guide students if they require learning and creating alongside students, and identify when they need skill-building, redirection, and encouragement (Larmer, Mergendoller, & Boss, 2015).

Furthermore, teacher-student relation enhances learning and metacognition and teacher guide students to improve metacognitive abilities which assist to comprehend thoughts and attitudes (Chiş & Havatzelet, 2007).

1.3.3 Assessment of PBL

McMillan (2014) presented a scorecard to summarize the relative strengths of assessment methods in evaluating various targets in table 3. The highest score is 5 as excellent and the lowest is 1 as poor. As considering the aim of this study, assessment of learning and thinking skills, assessment method must possess high scores in skills as well as products and deep understanding and reasoning. Performance assessment possesses the highest average score in terms of assessments of skills, products and deep understanding and conform well to assess students` performance, products or presentations in PBL.

Performance-based assessment is also known as authentic or alternative assessment (Airasian & Russell, 2008; Frank & Barzilai, 2004; Moursund, 1999;) and is not only applied at the end of PBL as summative to evaluate the product but also applied on the process to help students` learning by giving feedbacks and to enhance the quality of products and presentations. Therefore, it may include a set of tools to assess both the product and the process (Moursund, 1999). Besides implementation of formative assessment may identify and solve problems, monitor progress and reduce anxiety (Frank & Barzilai, 2004). Performance assessment provide opportunity for multiple assessment tools which reduce anxiety as well and supply more information to measure students` levels (McMillan, 2014).

Rubrics are appropriate tools to measure performance fairly and supply sufficient information what students must know and do as guiding them to increase quality of their work (Capraro, Capraro & Morgan, 2013; Popham, 1997). Summative assessment firstly focuses on evaluating the final product which is formed from short tasks. Likely formative assessment, rubrics conform for summative assessment (Capraro, Capraro & Morgan, 2013), and moreover reduce teachers` assessment duration (Frank & Barzilai, 2004; Goodrich, 1997).

In addition, rubrics are associated with evaluating students` skills which are hardly assessed by high-stakes tests. Criterion-based structure of rubrics aids to evaluate skills such as collaboration, communication, and self-management (Bell, 2010). On the other hand, individual assessment takes part in PBL because of standardized external tests for graduation and university acceptance. Therefore, traditional tests should be placed in PBL process to obtain individual performance (Capraro, Capraro, & Morgan, 2013; Larmer, Mergendoller, & Boss, 2015). Performance assessment is the most complicated assessment method due to combine of formative and summative assessments as well as concerning individual performance. It should not be ignored that performance assessment and rubrics could be new and students could not be familiar to them. Thus, assessment system could encourage and praise them (Moursund, 1999).

Chapter II RESEARCH METHODOLOGY

2.1 The Statement of Problem

PBL is an alternative method to teach and assess life skills in variety of courses throughout K12 schools to universities. Assessing PBL process and grading group product with only one score could cause ambiguity for results of the skills. Group presentation includes the making product and presentation. Mostly the product is the consequence of collaborative work and presenting the product is related to communication skills. It is ambiguous that giving the only mark is for which skill. Besides communication and collaboration in PBL, other skills such as critical thinking, self-management, ICT skills, etc. are frequently used and important to complete the product. If it is accepted that the given only mark represents the collaboration skills, educators lack of idea about students` communication and critical thinking skills. Thus all skills might be assessed individually and with its assessment instruments to obtain students` level, strengths and weaknesses.

The only given mark usually is for collaboration skills and is same to all group members. Having same mark can cause issues on teammates` minds. Low-level students could be satisfied with the group mark and can incline to social loafing. Hereby, high-level students may lose their motivation because of reluctant teammates and may doubt of the fairness of the assessment. Consequently, group members` individual participation should not be neglected and their contributions to group product might be taken into account to enhance their motivations. Even though only collaboration is assessed, group members might have both group mark and individual mark in order to prevent from social loafing (Webb, 1991).

Questionnaires, interviews and interview forms are important data collection instruments to assess development of the skills in the studies (Meyer & Wurdinger, 2016; Musa et. al., 2011; Ravitz and friends, 2012; Tamim & Grant, 2013). The development of the skills could not be equal the students` actual level in those skills and measuring the skills with such instruments could not reflect the actual level of the skill. The difference between development and actual level of skills should be illustrated with the following case. It is assumed that two students, one introvert and one extrovert, were treated by PBL and their communications skills 30 and 70 respectively. In the interview, introvert student should declare that s/he improved presentation skills much and extrovert student should state that s/he did not feel a significant improvement. Their levels of communication skills were assumed as 60 and 75 respectively. Self-awareness, the perceptions, the development of skills and some productivity skills could be assessed by questionnaires, interviews. Rubrics, tests

and written reports or essay could assess the skills well (Capraro, Capraro, & Morgan, 2013; Frank & Barzilai, 2004).

The objective of this study was how to assess high school students` actual levels on learning and thinking skills in chemistry course by the help of project-based learning (PBL). In this study collaboration, communication, and critical thinking skills was assessed separately by considering students` individual contributions on the group product.

2.1.1. Research Questions

1. How are group members` individual contributions assessed?
2. Is assessing individual contribution required in assessment of collaboration?
3. Is it important to assess the learning and thinking skills separately in assessment of PBL?
4. How does PBL influence students` self-awareness?
5. Is the level of improvement on a skill equal to student`s success on the skill?

   Sub-questions

6. Does cloud computing tool help to save time in PBL?
7. How is collaboration assessed by considering individual contributions?
8. How is communication assessed by considering communication methods and tools?
9. How is critical thinking assessed?
10. What are the other 21st century skills promoted by PBL?

2.1.2. Hypothesis Statements of Research

HS1: It is assumed that cloud computing tools help to assess individual contribution.

HS2: It is assumed that cloud computing tools enable to collaborate anytime and anywhere in order to save class time during PBL process.

HS3: It is assumed that assessing individual contribution is a requirement in assessment of collaboration and influence collaboration positively.

HS4: It is assumed that distinguishing the assessment of the skills (collaboration, communication and critical thinking) helps teacher to give more constructive feedback.

HS5: It is assumed that distinguishing the assessment of the skills enhances students` self-awareness.

HS6: It is assumed that the level of improvement on a skill may not reflect student`s achievement on the skill.

HS7: It is assumed that ICT and life skills promoted via PBL.

2.2 METHODS

2.2.1 Design method

The purpose of the study is to develop an assessment method for thinking and learning skills in order to observe students` attitudes and to reveal students` actual levels as numerical values via PBL. A mixed methods design, integrating both quantitative and qualitative data was used in this study (Creswell, 2009). This design was utilized to have quantitative data of students` level and to understand qualitative data of students` attitudes and thoughts deeply. Only one treatment, PBL, was conducted for the study and the quantitative and qualitative data were gathered at the same time. Data was given in results and interpretations were given in discussions.

2.2.2 Participants

The study was conducted with ninth grade and tenth grade students in a private international school in Prague. PBL was repeated with 1 ninth-grade class in first semester of 2017-2018 academic year since the school possessed 1 ninth-grade class and 1 tenth-grade class in 2016-2017 academic year. Age group was determined as 14-15. 40 Participants were from different counties and their backgrounds were different. They studied in English and all documents were in English. 6 students have insufficient English.

Groups are form by using their prior test scores. High level, medium level and low level student were determined. Majority was medium level students. There were a few low level students. High, medium, medium and medium, medium, low students were group to provide narrow heterogeneity and to enhance collaboration (Webb, 1991). Randomly one high level or one low student was selected and then randomly two medium students were selected. 10 three-member groups were formed and 5 two member groups formed due to the class size.

Having computer was important due to prepare presentations. All had computers and had opportunity to access internet at home. The school had ICT laboratory to search and prepare presentation and science laboratory to do experiments.

2.2.3 Data Collection Instruments

2.2.3.1 Collaboration Data Collection Instruments

A) Collaboration Rubric

A public product is the concrete part of group work and learning. Group members represent what they learn and how they work. Group productivity and students` collaboration skills, can be assessed by using their public products (Webb, 1995). A rubric is used to assess their group presentation and their collaboration skills while presenting. This rubric is adapted from presentation rubrics (Capraro, Capraro, & Morgan, 2013) and from another collaboration rubric ("6-12 Collaboration Rubric," n.d.).

In a good presentation, content must cover needed information with sufficient details and must reflect that students learn the topic. The level must be appropriate for their classmates and information must be beneficial for them. Visual appearance is also important for presentation to capture audience` attention. Organisation of the presentation and group cohesion reflect the students` collaboration skills. Starting with a good introduction, preparing sequence of information, sharing responsibilities among the members, working as a team are criteria for assessing individuals` collaboration skills.

B) Individual Contribution Rubric

Assessing a student's ability to learn from group activity and individual contribution is another purpose of collaboration. Unwilling students might be prevented from social loafing and other members could be motivated by monitoring and assessing individual work (Webb, 1995). A rubric is used to assess individual contribution and should motivate reluctant students and foster them to contribute. For online collaboration, the dimensions may change and be classified in terms of the aim such as purpose, quality, quantity, manner (Goodrich, 1997; Swan, Shen, &Hiltz, 2006). In this study, group members find and share texts, photos and video clips. After that they edit their files for their presentation. Besides, making own video of their experiment is obligatory. They utilize a technological tool to present their final product to their classmates. Therefore, text, photo, video clip, making video and presentation are the criteria of rubric. Scoring scale depends on quantity and quality of the shared files and their video of the experiment. On the other hand, each student may not be able to edit video or could not use a different presentation tools. Finding and showing video were considered as an extra credit due to these facts.

C) Weekly reports

Weekly reports are traced students` works and progression on the projects. The report paper includes three open-ended questions and duty table on the front paper. The fourth

question with table for communication is placed on the back. The first question, 'What did you do for project? `, revised the students` work at last week which could be their duties, decisions, problems related to project. The second question, ` What did you learn this week? `, searched the improvement on their knowledge and may be skills. The third question, ` What do you plan for next week? `, aims to sustain them on the project and tends to work weekly. The first question is more general and is assumed as 4 points and other questions are 3 points. Groups are composed of three students and it is assumed that each student might write at least one statement for each question.

2.2.3.2 Communication Data Collection Instruments

A) Communication Rubric

Communication Rubric was utilized to assess students` communication skills during presentation. Capraro et al. (2013) presents a rubric for communication. This rubric changed slightly. Speaker`s knowledge, comprehension of the topic and appropriateness of vocabulary, intonation and persuasiveness are significant. Body language must support and effectiveness of body language, facial expressions, gestures, eye-contact are assessed as well. Enthusiasm and confidence might be conveyed while presenting.

B) Weekly reports

The fourth question, `How did you communicate with your group members for project?` lead students to communicate and searches how often they communicated with which method such as face-to-face interaction, phone call, e-mail or instant messengers. Getting a grade reinforce them to interact more for project. Face-to-face interactions in the lessons are 3 points, other interactions are 1 point. Students get 1 point for each 5 instant messages. The maximum mark per week is assumed as 10 in order to tempt communication more.

2.2.3.3 Critical Thinking Data Collection Instruments

A) Critical Thinking Rubric

The rubric is composed of four scales: analyzing driving question, gathering and evaluating information, using evidences, justifying choices and considering alternatives.

Students` approach to driving question is checked. Identifying central aspect and their level of inquiry are investigated. Knowledge building is related to gather and evaluate information. While searching the answer of the driving question, students expose to a pile of information on internet. Using one resource could cause using unnecessary information and checking multiple resources are required. They should consider the quality of information before using in their presentations and evidences should be strong to support the idea. The final scale of the rubric is the justifying choices and the product. Students might explain their

ideas, defend their choices and use supporting evidences. The recognition of the limitations of their answers is important in order to express why they use such an answer.

B) Chemistry Reasoning Test

Subject-based multiple choice tests are recommended after a subject-based treatment because general content based multiple choices could be unrelated with taught topics and students` prior knowledge could affect the results (Haas & Keeley, 1998). In test, 2 cases were described and supported by tables. Totally 10 multiple questions asked with their justification part which students must explained with the evidence from texts and tables.

2.2.3.4 PBL Questionnaire

PBL questionnaire was used to assess how students perceive their learning environment. This questionnaire was retrieved and adapted for project-based learning (Dale, Nasir, & Sullivan, 2005). The questionnaire consisted of 14 items in four scales assessing the students' perceptions of the academic role and motivational effects of PBL, communication skills, collaboration and assessment methods in PBL. In addition, there were two items for their overall thought related to assessing PBL. The items were scored on a 5-point Likert scale.

2.2.3.5 Interview Form

Interview form includes 10 open-ended semi-structured questions in order to obtain students` experiences throughout PBL process as a qualitative instrument. Questions were prepared to reveal their opinions on PBL, chemistry, communication, collaboration, critical thinking, and ICT. The form was useful to understand that which student acquired and develop which skills.

2.2.3.6 Chemistry Unit Test

Chemistry unit test is a summative assessment in order to measure students` learning with regard to academic standards and is composed of similar questions on course book as well the previous chemistry tests. This test assesses students individually. Consequently, a blended model of performance test and traditional test is a superior assessment in PBL process (Capraro, Capraro & Morgan, 2013). In this study, chemistry unit test allows to compare between students` prior chemistry knowledge and their knowledge after PBL. The results of chemistry unit tests crosscheck students` responses in questionnaire and interview form.

2.2.4 Data Collection Procedures

At the beginning of the study, students` critical thinking skills were tested. Students were grouped based on the results from their prior chemistry scores. High level, medium

level and low level student were determined. Majority was medium level students. There were a few low level students.

In the first week, the teacher explained project-based learning, how to form and work as groups, and presented assessment tools; weekly reports, rubrics and test. Randomly one high level or one low student was selected and then randomly two medium students were selected. 2 types of 3-member groups were formed as high, medium, medium students and medium, medium, low students.

Teacher gave more topics than the number of group and allowed to decide the topic as a group till next week. At the beginning of the lesson, they signed their group contract. When they were in ICT lab, they logged in their Gmail account and sent mail to teacher, and started searching their question. Meanwhile teacher shared instructions and rubrics as group folder. Students searched the answer of their questions and a related experiment. After completing their projects, they presented in the classroom in front of their classmates. Weekly Data Collection Process (Table 6) is given below.

	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
Instructions and formation of groups	√							
Weekly reports (Collaboration 5 % each)		√	√	√	√			
Table of frequency of communication (Communication 10 % each)		√	√	√	√			
Critical Thinking Rubric (Critical Thinking 40 %)				√	√			
Communication Rubric (Communication 80 %)						√	√	
Collaboration Rubric (Collaboration 60 %)						√	√	
Chemistry Reasoning Test (Critical Thinking 70 %)								√
Chemistry Unit Test								√
PBL Questionnaire								√
Interview Forms								√

Table 6. Weekly Data Collection Process

Chapter III RESULTS OF DATA ANALYSIS

3.1 RESULTS OF COLLABORATION INSTRUMENTS

3.1.1 Weekly Reports

In the first reports slight information related with chemistry was stated and general statements were written such as learned the method and searching for information. However, after doing experiment, nine groups reported their experiments and the chemistry behind the experiment by giving details. Some of them wrote how experiment worked and its conditions, and some of them wrote the reactions and results.

The mean of each weekly reports of Class A is higher than other classes. Their statements were clear and included details of researches and presentation. In the last report, the mean of Class A is 8.00 out of 10, the highest mean of weekly reports in the study. Other class means usually increase and the fourth weekly report means possess the highest among the class means. The effect of experiment is observed in this report as noticing more chemical knowledge and information related with reactions.

3.1.2 Collaboration Rubric

In collaboration rubric, content and visual design, assess group productivity and organization and cohesion assess teamwork and in-group collaboration skills.

All groups presented needed materials, steps and results of experiment and made video of their experiment to explain their research question. However, the presentations of G1, G2, G5, G6, G8, and G10 lacked of sufficient explanation of chemical content. The visual appearance of the presentations of Class A and Class C prepared well visually but the most of presentations of Class B class were prepared carelessly. The majority of the groups obtained more content score than visual appearance score. The groups of Class A showed an addition video to explain their topic and placed some gifs to attract classmates` attention. Therefore, their visual design scores were higher than others` visual design scores.

Organization means the structure of the presentation; starting with purpose, clarifying the chemical content and experiment, supporting the topic, underlying the major parts, concluding with the summary. Cohesion refers to share the responsibilities and team work among group members. Presentations of Class C were similar to presentations of Class A as sufficient introductions without an attractive beginning and mentioning the purpose related with chemical content. Groups generally performed quality teamwork in presentations. Consequently, introductions, organizations, conclusions of presentations were usually sufficient. Only four groups summarized their presentations. Students generally reflected

quality teamwork except three groups, G8, G9 and G13. The means of organization is lower than the means of group productivity for all classes and all groups except G12 and G14. Assessing only the group product in PBL may not reflect students` all collaboration skills such as teamwork and organization.

3.1.3 Individual Contribution Rubric

Individual contribution rubric includes texts, photos, video clips and/or animation, making video clip and presentation. Students worked over Google Drive in ICT lab in the school while making projects. Working on Google Drive offers accessibility after school and at home since their folders are shared online. The date and time reflect group members` efforts and how cloud computing tools save time. Time of some versions belonged to after school such as 7:08 pm and 8:55 pm. These students worked at home individually like in 7:08 pm and 6:52, and together such as 8:55 pm and 10:02 pm. When working times in the version history of the presentation are investigated, all groups of Class A, worked individually or together at least 4 times after school.

Group productivity score is normally higher than individual contribution score since each member gains group productivity score from others` contribution. When group productivity of a group is high and higher than all individual contribution scores, it could be stated that this group may perform collaboration and/or cooperation well such like G15. When these two scores of G11 compared, group productivity score, 85%, is higher than all individual contribution score with big differences of group members which obtain 83.33 %, 83.33 %, and 33.33%. The difference between students` group productivity scores and their individual contribution scores is significant ($p<0.05$) (Table 16).

3.2 RESULTS OF COMMUNICATION INSTRUMENTS

3.2.1 Weekly Reports

The percentages of communication frequencies of the groups did not reflect a general trend. Some groups communicated more in the second week –G3 and G7- , in the third week – G1, G2, and G9- or in the fourth week - G4, G8, G10, G12, G14, and G15-. The last week scores are usually higher than others but even there is not regular pattern for this fact because G1, G5, and G6 reduced their scores in the fourth week. Students` in group communication depends on individual necessaries and communication frequencies are quite personal. The class means of the communication frequencies had increased slightly week by week despite of lack of a trend in communication frequencies of the groups. The class mean of communication frequency scores of Class A is higher than other classes in each week.

3.1.2 Communication Rubric

The Communication Rubric is consisted of two parts, comprehension and presentation skills. The class means of understanding and vocabulary part is higher than the class means of presentation skills. Particularly the means of Class A (M=83.33 and M=81.67) is high in both parts which are close values. The majority of the students in Class C comprehended the topic, and then explained as well. The difference of the means of the parts of Class A is slightly bigger than other classes. Several students looked at the board or front of them instead eye-contact and body language. They could not transmit information well. On the other hand, several groups obtained slightly more presentation skill score than understanding and vocabulary scores such as G8, G9, G12 and G14.

3.3 RESULTS OF CRITICAL THINKING INSTRUMENTS

3.3.1 Critical Thinking Rubric

Students` approaches to driven question depended on identifying main aspects and did not broaden inquiry and not search other possible points of view. G13 saw only one point of view and unfortunately G9 did not find possible view in the first week and then focused on one answer. All groups, especially G7, G12 and G14, gathered information from various sources. This scale possessed the highest average for the all groups. Although several students from different groups explained the content of presentation, they as a group did not explained clearly. Unsuccessful students could not explain their parts clearly and decreased their group average. While gathering information, multiple resources were utilized and the class means of gathering information is higher than that of other criteria. The class means of analyzing question and using evidence were around 50 % for all classes. The lowest class means belongs to justifying choices.

3.3.2 Chemistry Reasoning Test

Chemistry Reasoning Test is a subject-based multiple choice test with justification parts, including 10 questions. 2 cases related with chemistry subjects were supported by tables. While analyzing the results of chemistry reasoning test, 3 students in each class defended their answered well and obtained marks in spite of selecting wrong answer in multiple choice. Two students individually obtained more justification average than their multiple choice average. The majority of group means of multiple-choice part were higher than group means of the justification parts. Only three groups obtained same group means of two parts. Low-level and several medium-level students usually selected only an option without explanation.

3.4 PBL QUESTIONNAIRE

The means of items are higher than 3.5 and close to 4 and positive influences of PBL are observed on the scales. The means of scales of Class B are lower than those of other classes.

	Class A		Class B		Class C					
Scale	**Mean**	**St Dev**	**Mean**	**St Dev**	**Mean**	**St Dev**	**F**	**p**	**Mean**	**St Dev**
Efficiency of PBL	3.94	0.76	3.38	1.01	3.75	0.98	4.65	0.01	3.68	0.95
Collaboration	3.56	1.18	3.51	1.50	3.58	1.50	0.03	0.97	3.55	1.27
Communication	3.96	1.00	3.12	1.40	4.00	0.78	5.23	0.01	3.68	1.16
Assessment	3.57	1.08	3.05	1.15	3.68	1.27	5.88	0.00	3.41	1.20

Table 27. The comparison of variables in terms of classes

Almost all students agreed that PBL enabled them to communicate with classmates. Class B did not enjoy discussing on topics with classmates. Even though, the mean of this item (Q10) has the lowest value among all items.

2 items, Q2 and Q16, helped to obtain students` overall thought and also crosschecking their responds. Class A considered to do projects again (M=3.92) and did not think about PBL as wasting time much (M = 1.916). Class B was unsure whether doing projects again or not (M=3.00) since most of them considered that PBL wasted class time. The mean of Class C on item, Q2, (M = 2.583) was between disagree and undecided. Some of them considered as wasting time much but some did not.

3.5 INTERVIEW FORM

The students` responses on the interview form were analyzed to revealed which skills benefited for the project, which skills pupils improved and how they assessed their PBL experiences. The results of the main questions in the form were given in the summary.

Q6) What are the similarities and differences between your regular class activities and the project?

Class B emphasised `individual learning and understanding more` and Class C concerned `learning with demonstration`. Class A mentioned both of them with high frequency. `Working Together` is regared as an important difference in all classes and Class A and Class B pointed out `communication` as a significant difference. Besides online research and individual learning, `presentation` was a major difference between the methods for Class C.

Q7) What types of benefits do you think you gain from the process of project? Can you give examples of the benefits you obtain?

a) Chemistry

Almost all students underlined `learning the topic` and some students of Class A and Class B added `understanding better`. None of Class C students considered that they understood better by the help of PBL as low frequency of the item ` Individual Learning and Understanding More` in the previous question. The results of benefits of PBL with regard to chemistry possessed similaraties with the differences between the methods.

b) ICT

According to the majority of students main three benefits of ICT are `making presentation better`, using Google Drive` and `video editing` with various frequencies in the classes. The frequency of `research better on internet` follows the main responses.

c) Teamwork

A number of responses of this session typically are related with collaboration and cooperation. The common statement is `working together well`. The responses related with duties such as `getting duties faster` and `sharing duties` are categorized under the title `cooperation` . Class B students replied this section with different responses. The cooperation-related responses possessed the highest frequency. The frequency of `making friend` could be explained by considering the number of new students in the classes. In Class B and Class C the number of new students was higher than that of in Class A. Therefore, several students made friends during PBL and expressed this situation. In Class C, the frequency of `time management` (f=16.67) is higher than that of other classes.

d) Communication

The most common student respond is `communicate better` in all classes with various frequencies. The frequency of this respond is 50.00% or more in Class B and Class C. The second most frequent respond is `more confident while speaking` in Class A (f=25.00%). PBL gave opportunity them to communicate with their classmates and the highest frequency of benefits with regard to communication is `communicate better`. `More confident while speaking` and `good at using messenger or other tools ` are other common responses. Other responses are personal and reveals students` communication level. Two students who had poor English replied as learning new words and improving the language. Few introvert students expressed themselves as becoming more confident. Several students who possessed good communication skills answered as better explanatory skills and being more emphatic.

Q8) What types of skills do you think you develop or learn?

The students of Class A and Class B improved their communication skills. The total frequency of communication and communication-related skills, confidence while speaking and presentation skills are similar, given respectively (f=66.67%) and (f=68.75%). Moreover, the total frequency of collaboration and collaboration-related skills are similar as well. Few students of Class C improved communication and collaboration skills. Their common response is `learning the topic` and `time management` and `ICT skills` are mentioned in all classes.

3.6 CHEMISTRY UNIT TEST

Chemistry unit test is used as a summative assessment at the end of PBL process. Students` test results are compared to the average of their previous test results and analyzed by using independent t-test. The difference between all students` means of the previous tests and chemistry unit test is significant ($p<0.05$). Class means of chemistry unit test are higher than class means of previous tests. However only the difference between Class C students` the means of the previous tests and chemistry unit test is significant ($p<0.05$). Other classes independent t-test results are not significant ($p>0.05$).

3.7 DISCUSSION

3.7.1 How are group members` individual contributions assessed?

As an alternative assessment tool, rubric is proper for PBL process in order to guide students what to do and to give feedback students and teachers. Individual accountability is reflected effectively by the help of application of rubric (Capraro, Capraro & Morgan, 2013). Hence, individual contribution in performance assessment should be assessed by using a rubric. In this study, students` contribution can be occurred in five components with three scoring scales, depending on quantity and quality of the components. Rubric for online contribution was edited and named as individual contribution rubric (Şentürk, 2016).

Working times in the version history of the presentation are investigated and notices that after school time G1, G2, G3, G4 from Class A, G7 from Class B, G11, G12, G14 and G15 from Class C students worked on presentation together or individually at least twice during PBL process. These groups` individual contribution and group productivities are compared to other groups which most probably work on project only in classes. The difference between groups which worked after school as well and worked only in school is significant ($p<0.05$) in terms of both individual contribution scores and group productivity scores (Table 45). Images of Google Drive which display dates and users of every upload and edits provide the hypothesis HS1 `It is assumed that cloud computing tools help to assess individual contribution. `

It can be said that duration in ICT lab was not enough to prepare for a well-done project. This fact could justify the critique on PBL as `PBL requires more time due to doing research, writing reports and preparing product and then allocating more time on academic calendar increases pressure on teachers.` In logs of Google Drive, most of the groups -9 groups out of 15- completed some duties of the project after classes. It was possible to work together anytime by the help of cloud computing tools. This fact validates the hypothesis HS2 `It is assumed that cloud computing tools enable to collaborate anytime and anywhere in order to save class time during PBL process. `

3.7.2 Is assessing individual contribution required in assessment of collaboration?

The difference between group productivity and individual contribution is significant ($p<0.05$) and this means that assessing individual contribution is a requirement for collaboration. Otherwise social loafing could be occurred in PBL process. Few low-level students did not make sufficient effort and satisfied with group mark. Indeed, these students lower their group members` motivation.

Average marks of group productivities, individual contribution and Q15 (Individual assessment is needed and important in group project) are compared for HS3: `It is assumed that assessing individual contribution is a requirement in assessment of collaboration and influence collaboration positively.` It is clear that students who considered that individual assessment was important worked more for group products, prepared better products and obtained higher group productivity score. On the interview form, Q10, 7 students mentioned that individual assessment was required.

3.7.3 How is collaboration assessed by considering individual contributions?

Group productivity and organisation scores of all groups were given in Table 51 and analysed by ANOVA in order to verify whether the difference between them is significant or not. The difference between means of group products and organisation is significant ($p < 0.05$). Therefore, assessing organisation and cohesion is a requirement for a balanced assessment of collaboration in PBL. Group productivity, organisation and individual contribution are graded as same weight which is 30 %. Weekly reports, are graded as 20 %. Totally the grades of assessment tools make 110 %. Editing parts in individual contribution rubric could not be done by students who do not know how to edit video. Moreover, the main objective of the study is to assess learning skills, not to assess ICT skills. Due to these facts and considering Moursund`s (1999) recommendation as encouraging and praising students, 10 % is granted.

3.7.4 How is communication assessed by considering communication methods and tools?

The difference among three constituents of communication is significant ($p < 0.05$). It can be said that all data collection instruments of communication are required for assessment of collaboration. Components of communication rubric were graded 40 % of overall mark. Each table of communication was graded 10 % and percentage weight of these tables was equal to 30 % and communication marks were summed up to 110 % and it is decided as 110 % due to encourage students to communicate while doing project and rewarding students during assessing.

3.7.5 How is critical thinking assessed?

In Table 55, the difference between the parts of the chemistry reasoning test was statistically significant, $p < 0.05$. Therefore, their grade weight must be different due to the influence of justification part. Students` rubric scores were compared with chemistry reasoning test by ANOVA. The difference among three constituents is not significant ($p > 0.05$). One assessment tool, the critical thinking rubric or chemistry reasoning test should be used to measure students` critical thinking skills in PBL. However, if chemistry reasoning test is selected as an assessment tool, both components must be applied for healthy results due to significant difference between them in Table 5**7.**

3.7.6 Is it important to assess the learning and thinking skills separately in assessment of PBL?

Students` means of collaboration, communication and critical thinking skills were compared by ANOVA. The difference among means of three skills is significant ($p < 0.05$) and validates HS4 `It is assumed that distinguishing the assessment of the skills (collaboration, communication and critical thinking) helps teacher to give more constructive feedback.`

Students` different characteristics are noticed after analysing the table 58. For instances, Student 40` scores, (93.50, 81.00, 36.00) reflects a wide range and implies that he was very good team player, good communicator with insufficient critical thinking skills. On the contrary, student 22`s scores, (46,75, 66.00, 79.00) indicate good critical thinker but not a team player. Each student is different despite common categories and distinguishing the assessment of the skills reveals their strengths and weakness well.

3.7.7 How does PBL influence students` self-awareness?

Collaboration

In the interview form, for Q8, 3 students (f=18.75%) replied that they developed their collaboration skills. Although most of students in Class A and Class C considered themselves collaborative sufficiently, several of them developed some collaboration skills such as cooperation, leadership and negotiation. Most of Class B students described themselves as competitive or close to competitive.

Communication

Students mostly were aware of level of their communication skills. Students who had poor English had opportunities to improve their language. Many students agreed with communicating better with group members. Students who had sufficient communication skills expressed that they became more confident and even few developed explanatory skills. In other word, their self-awareness increased and their communication skills improved with regard to their levels.

Students` responses support the hypothesis HS5 `It is assumed that distinguishing the assessment of the skills enhances students` self-awareness.` Students obtain appropriate feedback by the help of separating the assessments of learning and thinking skills.

Subject Knowledge

In PBL Questionnaire, students were asked whether this method helps them to learn better or not (Q3). The class averages of this item are respectively M=3.92, M=3.77 and M=4.25. In majority of Class C students responded this item as agree and strongly agree. Comparison of the the average of previous chemistry test scores and the chemistry unit test score asisted to validate self-awareness in knowledge of chemisty. Students could comprehend that they could learn the subject without PBL and could not accept the increase on test score as a development.

3.7.8 Is the level of improvement on a skill equal to students` success on a skill?

Self-awareness might not be mixed up with actual level. Competitive students worked with teammates and improved their collaboration skills. This does not imply that they are going to obtain very good scores in the assessment. In the improvement they compare themselves with their previous skills. In the assessment their skills are measured by criteria on rubrics or test, not their initial positions. Oppositely, a student, having good communication skills, could not improve his/ her communication skills in PBL process and it does not mean that his/her communication skills score is going to be insufficient. The frequencies of the responses of Q8 (What types of skills do you think you develop or learn?) are compared to collaboration and communication rubric scores in Tables 60 and 61. More students in Class B declared that they improved their collaboration skills and their averages

of collaboration rubric scores are lower than other classes. Similarly, it the table 60 more students in Class B declared that they improved their presentation skills (31.25%) and their averages of presentation skills are the lowest among the classes (M=55.00). Although self-awareness and improvement of social skills could be measured by using interviews and questionnaires, the results of such data collection instruments could not indicate the students` actual levels. Comparison of self-awareness and rubric scores assists to validate the hypothesis statement, HS6 ` It is assumed that the level of improvement on a skill may not reflect student`s achievement on the skill. `

3.7.9 What are the other 21st century skills promoted by PBL?

In the interview form, ICT section of Q7 gathers data which students obtained benefits of PBL process in terms of ICT skills. The frequencies of ICT-related results are given in Table 43. `Making presentation better`, `research better on internet` and `Using Google Drive` possessed the high frequencies.

In all classes, `time management` is an answer as a developed skill. `Responsibility` is also another skill which is stated by students of Class A and Class C. The frequency of responsibility is compatible with the frequency of cooperation. Heterogeneous group composition could enable leadership skills of high-level or middle-level students. Indeed, only one case pointed out the improvement of leadership skills which was in Class A. Students` responses in interview form, the results in Tables 63 and 64 validate hypothesis statement 7, HS7 `It is assumed that ICT and life skills promoted via PBL.` While working in PBL, skills are integrated and cannot be completely isolated. if these skills are not assessed, the improvement of the skills may be less. Slight improvement of such skills might be related to lack of assessment as stated in OECD report (Ananiadou & Claro, 2009).

3.8. CONCLUSION

Performance assessment in PBL environment possesses complex structure and assessment of learning skills make it more complex. The complexity of PBL deters teachers to use PBL or tends to assess only group product. Giving one same score for all group members inhibits students` motivation and PBL process. Group product provides positive interdependence in group, however individual accountability should not be forgotten in order to prevent from social loafing and to sustain motivation. Results in Tables 47, 48 and 49 and students` responses on interview form support the necessity of individual assessment and verifies hypothesis statement 3 `assessing individual contribution is a requirement in assessment of collaboration and influence collaboration positively.` Therefore, individual

assessment is required for appropriate assessment of PBL and this circumstance makes the assessment even more complex. Technological and cloud computing tools could be incorporated to PBL in order to mitigate its complexity. In internet era, such tools facilitate not only PBL process but also the assessment. Cloud computing tools keep log of each user`s each uploads and each edits. In other words, they make visible students` individual contributions and teachers evaluate the contribution by following pupils` activities on clouds. Hypothesis statement 1 `cloud computing tools help to assess individual contribution.` was validated by using version histories of the presentations on cloud computing tools. On the other hand, cloud computing tools can solve duration problem of PBL which require more time than traditional teaching. Some researches indicated that teachers were unwilling to apply PBL due to uncertainties on duration of PBL or taking more time (Sahin, 2015; Thomas, 2000). Figures of version histories pointed out that most of pupils kept working on their project at their homes. Table 44 reveals such students` achievements and validates hypothesis statement 2 `cloud computing tools enable to collaborate anytime and anywhere in order to save class time during PBL process.`

The final products of PBL are a video clip of an experiment and performing a presentation in which collaboration rubric is utilized to assess the quality of the presentation and group cohesion. Indeed, collaboration is usually assessed with communication in presentations. Although distinguishing communication and collaboration is difficult, it should be struggled to assess the skills clearly and to give correct feedback. For instance, a student could possess advanced communication skills and could perform well without contributing the final product, writing on reports and participating teamwork. Evaluating his/ her high performance in presentation misleads his/ her collaboration skills. Results in Table 58 verifies hypothesis statement 4 `Distinguishing the assessment of the skills (collaboration, communication and critical thinking) help teacher to give more constructive feedback.` Students` skill scores are presented in Table 59 and display the fact that each student was at different level of the skills. Another benefit of distinguishing the assessment of the skills is related with students` self-awareness. For example, some students developed their skills while comparing to their previous levels. Two students who lacked of sufficient English stated that they improved their communication skills and learnt new words. The majority of students improved their communication skills. Several of them became more confident in speaking or improved presentation skills. Even one student responded as improving empathy. Low-level students improved vocabulary and high-level students improved presentation skills

and empathy. Thus, almost all of them acquired different levels of skills with regard to their previous levels and their potentials. Particularly rubrics guide students by representing the criteria and expectations to reach standards. Students` responses on interview forms support the hypothesis statement 5 `distinguishing the assessment of the skills enhances students` self-awareness.` as indicating their strengths and weaknesses.

Self-awareness may depend on the development of a skill in which compared students` circumstances between before and after treatment. Assessing students` skills implies to reveal the actual level of the skill that students` performances are compared to criteria on rubric. Furthermore, it is significant that the improvement on a skill may not reflect actual levels of student`s skills. In this study, an introvert student stated that she improved her communication skills and became more confident. However, her communication score was less than some students who meant slight development on communication skills or even no development. As in the example, results in Tables 61, 62 and 63 assist to validate the hypothesis statement 6 `the level of improvement on a skill may not reflect student`s achievement on the skill. `

Several students improved ICT skills while using technological tools for searching information and visual aids, making presentation and video of experiment, communication and collaboration. Besides, PBL improved life skills such as time management, leadership and responsibility slightly which are integrated with collaboration and communication. Results in Tables 63 and 64, are validated hypothesis statement 7 `ICT and life skills promoted via PBL.` Slight improvement of such skills might be related to lack of assessment.

Teaching and assessment of these skills might be integrated to education by considering individual contribution and distinguishing the assessment of learning and thinking skills. Technology assists teachers to cope with the complex structure of PBL as offering multimedia resources, tracing students` contribution and saving allocating classroom time. Above all, the schools and educational systems exist to raise well-equipped people to society which expects possessing such skills. Therefore, educators should keep training the skills as much as they can despite its difficulties.

3.9. SUGGESTIONS

The actual points for assessment tools should be given during the process and the end of PBL. Hence the overall score of the skill is obtained easily by adding the points of tools. If the scores of assessment tools are given as percentage, teachers must calculate overall skill

score by considering the percentage weights of the assessment tools. Therefore, using actual points saves assessment time. Teacher grade sheet should be used for grading which is attached as appendix H.

Teachers also could collaborate in the schools and offer to choose a subject for PBL. Each teacher could assess fewer students who select their favorite subject. Therefore, the opportunity to select subjects could motivate students and reduce teachers` workload.

Rubrics could be new tools for some students who could have not acquainted with them. Few activities can be assessed by using a rubric before implementing PBL to cope with this issue. In addition to rubrics, an activity could be assign to use cloud computing tools before applying PBL in order to be familiar them. This could be helpful for some low-level students.

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