Improving the Learning Effectiveness of Information System Analysis and Design Courses with Collassion Learning

Dwinita Arwidiyarti, Khaerudin, and Basuki Wibawa

Abstract—**The information systems analysis and design course are compulsory in the Information Systems Study Program. The majority of the graduate profiles demonstrate a great level of experience as systems analysts. Every year the number of students in this program at the University of Technology, Mataram, with scores below B is average 37.35%. This value corresponds to the annual student population being unable to conduct the course activities effectively. Therefore, the purpose of this research is to generate an appropriate learning model for the information system analysis and design course to improve higher-order thinking skills. The methodology involved research and development (R&D) that combines two learning development models, termed research and information collection. This research occurs as the first stage of Borg & Gall's model and the Step of System Approach Model of Educational Research and Development, adapted from Step Learning Design by Dick & Carey. Based on the analysis results of student demands, literature review, and the reference to existing problems, the need to develop a learning model for the information systems analysis and design course appears very essential. This is achieved by adopting a problem-based learning model known as "Collassion", mainly supported by information and communication technology in relation to collaboration and discussion. A validity test was subsequently performed by 4 experts and the model effectiveness was determined, using product effectiveness analysis. The posttest average score was attained at 81.21, with 82.76% of student completion rate in accordance with the specified minimum competency standards. This score has increased significantly up to 72.41% from the pretest mean value at 43.69, with a percentage of completeness of 6.90%. Furthermore, the effectiveness test results showed the ability of Collassion Learning in enhancing the learning effectiveness of the sample course.**

Index Terms—**Analysis and design of information systems, collassion learning, learning models, problem-based learning.**

I. Introduction

The Information Systems Study Program is mainly focused on computer software, with a core objective of producing graduates capable of analyzing and designing information systems according to stakeholders' needs. Based on the curriculum by the Association for Computing Machinery, which is the reference for the study programs in the field of informatics and computers globally, information systems study programs are required to incorporate information systems analysis and design courses. This module describes the activities at each stage of the system life cycle, with emphasis on system analysis and design phases. In reference to the cognitive domain of Bloom's Taxonomy revised by Anderson & Krathwoh1 [1], the material contents include analysis, evaluation, and development at levels 4 (C4), 5 (C5), and 6 (C6), respectively. As a consequence, students are expected to participate in regular assignments, both within and outside lecture hours. This is to build sufficient competencies in information systems analysis and design, as well as enhance higher-order thinking skills (HOTS) that are all-encompassing [2]. These proficiencies are very essential in the practice of critical, logical, and creative thinking in solving complex problems. Higher-order thinking skills are also important for education and general human survival [3]. Newman (1990) defined HOTS as skills that challenge students to "interpret, analyze and manipulate information" [4]. Furthermore, learning models play a valuable role in developing these talents, particularly as regards the academic sector [5]. Active participation in learning activities, such as problem-solving based on hypothesis generation, evidence collection, and arguments, tends to improve higher-order thinking skills among students [6]. Therefore, the ability to analyze and design information systems is a very significant pre-requisite for information systems study programs, including graduate profiles as systems analysts.

The current challenge involves the number of students with scores below B in the information system analysis and design course constantly occurring above 30% and closely indicating 40% of the total class population. This student figure attained 37.90% in the second semester of the 2018/2019 session. Meanwhile, the scores for the first and second semesters of 2019/2020 were estimated at 35.36 and 38.78%, respectively. Based on critical observations, an average value of 37.35% was annually specified. This estimate corresponds to the yearly student population being unable to conduct information system analysis and design activities effectively, as well as demonstrate higher-order thinking skills.

Furthermore, the grouping of values at the University of Technology Mataram, were categorized into five, including A, B, C, D, and E, with ranges between 80-100, 70-79, 60-69, 40-59 and 0-39, respectively. The learning achievement of a course is considered successful if the student population with at least 70 score (B) obtains a minimum of 80% of the total participants. Based on this estimate, the common condition for the information system analysis and design course is the reduction of student percentage with scores below B to a

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The authors are with Universitas Negeri Jakarta, Indonesia (e-mail: DwinitaArwidiyarti_7117157697@mhs.unj.ac.id, khaerudin@unj.ac.id, bwibawa@unj.ac.id).

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maximum of only 20%, corresponding to high-level thinking skills.

The present learning model considers a problem-based approach by forming small student groups that engage learning and discussion activities within and outside the classroom. However, without lecturers' involvement in terms of monitoring and providing direct feedback, achieving optimal results appears relatively complex. Certain factors are responsible for the high percentage of students with scores below B, including limited lecture hours of 150 minutes per week, poor performance on outdoor assignments, as well as difficulties in monitoring and providing direct feedback.

Based on the analysis of student needs data obtained using questionnaires filled by 131 students, the following conclusions were drawn:

1) 1.87% of students experience difficulty in converting personal ideas into system design drawings.
2) 2.83% of students experience difficulty in determining the relationship between symbols and tables.
3) 3.97% of students agreed with cases where the lecturer gave practice questions to be completed in groups outside class hours.
4) 95% of students want an application to aid studying lecture materials for Information Systems Analysis and Design courses.

Based on these conditions, the present research appears very critical in generating an appropriate design for the information systems analysis and design course as well as its procedural and conceptual models in enhancing higher-order thinking skills.

II. Methodology

Research and development (R&D) methods were applied in this research. According to Borg & Gall, "Educational R&D is an industry-based development model where research findings are used to design new products and procedures. These innovations are systematically field-tested, evaluated and refined until specified criteria of effectiveness quality or similar standards are fulfilled" [7]. Meanwhile, Gay (1999) referred to R&D as an attempt to develop an effective product for school applications, and not to test the theory [8]. The term "product" describe material objects, such as textbooks and instructional videos, as well as processes, including learning or course preparation methods [7]. This R&D technique combined two learning development models, termed "The Dick & Carey's Step of System Approach Model of Educational Research and Development" and the "Borg & Gall's model". The Dick & Carey's approach involves 10 mandatory stages, such as assessing needs to identify goals, conducting instructional analysis, analyzing students on contexts, writing performance objectives, developing assessment instruments, forming instructional strategy, creating and selecting instructional materials, designing and conducting formative instructional evaluation, revising instruction as well as designing and conducting summative evaluations. However, the model's weakness was the absence of data collection step originally considered. As a consequence, research and information gathering was then added as an initial step corresponding to the first stage of the Borg & Gall model. Fig. 1 shows the application of Collassion Learning in the seventh step, which is the novelty of the present research.

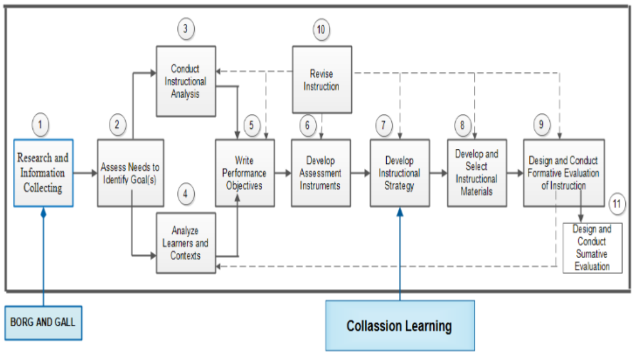

Fig. 1. The research and development stages.

The first R&D stage involved observing the continuing course activities, followed by the identification of the learning objectives in the second phase. Learning analysis related to models, strategies, skills, procedures, and tasks matching the learning objectives formed the third stage. This was followed by determining students' capacities, in terms of learning characteristics as well as the newly required skills. The fifth step translated the learning needs and goals into more specific performance targets. Meanwhile, the sixth stage incorporated certain activities for developing assessment instruments, based on written performance objectives. The development of learning strategies in the seventh stage assisted to achieve the learning and performance objectives, using the Collassion model, while test development in the eighth stage measured students' abilities. Furthermore, the design and formative evaluation of learning occurred in the ninth phase, while the tenth encompassed the revision of instructional activities.

III. Results and Discussions

Preliminary data collection was used to determine the suitable learning model for student course needs. A total of 131 students of information systems analysis and design participated in this research. The following results were obtained:

1) 99% of students desired direct assignment feedbacks from lecturers.
2) 88% of students expected lecturers to monitor the discussion process outside school hours.
3) 97% of students demanded a more effective learning approach, integrated with information and communication technology.

In addition to the use of data in determining students' needs, the present research reviewed several previous research related to problem-based learning in universities, among others. These assessments also included statistics courses in engineering with the title: Application of the Problem-Based Learning Method in the Discipline 'Statistics for Engineering' [9]; for learning English with the title: The Application of Problem-based Learning Approach in English Grammar Instruction: A Pilot Study [10]; for the field of engineering at the University of Huelva with the title: A review of Problem-Based Learning applied to Engineering [11]; for Instrumental Analysis Course with the title: Application of problem-based learning in instrumental analysis teaching at Northeast Agricultural University [12]; for learning in the field of science with the title: Problem-Based Learning, An Efficient Learning Strategy In The Science Lessons Context [13]; for learning in the fields of Science, Technology, Engineering and Mathematics (STEM) with the title: Effectiveness of Computer-Based Scaffolding in the Context of Problem-Based Learning for Stem Education: Bayesian Meta-analysis [6]; for learning in the field of teacher education with the title: Problem-Based Learning Pedagogies in Teacher Education: The Case of Botswana [14]; for learning in the field of Physics with the title: The Effect of Problem Based Learning (PBL) Instruction on Students' Motivation and Problem Solving Skills of Physics [15]; and for learning Software Modeling with the title: Development of Instructional Design Models Based on PBL Model for Software Modeling Course at the Information Technology College in Indonesia [16].

Based on the analysis results of students needs, literature review and the existing problems, the need to develop a learning model for the information systems analysis and design course appears more significant. Learning model is an important element in student learning activities and its appropriate implementation help to facilitate an effective teaching and interactive process [17]. The potential model is expected to be problem-based, using information and communication technology for easy collaboration and discussion. Active communication and collaboration among students and with lecturers, are essential in generating quality learning. These conditions are a characteristic of student-centered learning, applied with a problem-based learning model, according to the National Standards for Higher Education of the Republic of Indonesia. The problem-based learning model promotes students to identify inherent challenges and provide relevant solutions [18]. This mechanism is used to develop knowledge and problem-solving skills, based on real life situations [14]. Dynamic issues that require students participation in formulating and solving problems are addressed, in terms of both content and context experience. Problem-based learning techniques are derived from the constructivist learning theory that describes learning as an active and constructive process in developing solutions to problems, using critical and creative thinking, analysis, synthesis as well as problem-solving skills [19]. In practice, students no longer appear passive, but tend to build a dialogue learning environment and improve critical thinking. The model also utilizes collaborative methods, where small student groups work jointly to maximize learning outcomes [20]. Collaborative learning broadly refers to work done by students in exploring solutions to problems or preparing a project, including various interaction strategies [21].

Furthermore, problem-based learning model as a student-centered instructional approach, is widely applied across universities worldwide [22]. The collaboration process is also facilitated by the use of modern technology [23]. Alongside the development of information and communication technology, the learning process also demonstrates a positive impact by utilizing ICT-based devices. These gadgets accelerate the learning transformation and communication between lecturers and students, without space and time constraints [24]. Therefore, in order to apply technology to support learning, a solid knowledge-based learning model appears very necessary. This is in addition to appropriate learning designs, as well as a sound understanding of student needs and characteristics. The requirements help to enhance effective communication between students and lecturers, with an impact on continuous improvement [25]. Problem-based learning models are implemented in various disciplines, including informatics and computers, where the emphasis is based on individual abilities in designing and developing various computational algorithms.

Previous reference assessments illustrated that research related to problem-based learning models is currently relevant, with application in various science fields. Particular instances reported the integration of information and communication technology. Therefore, the need to investigate the development of learning models for the information systems analysis and design course, with ICT support appears very essential. This potential model is termed "Collassion Learning", where Collassion stands for collaboration and discussion. The approach help students collaborate and discuss effectively, both within and outside lecture hours, devoid of space and time constraints. As a consequence, lecturers are able to monitor student activities and provide direct feedback.

A. The Concept of Problem-Based Learning

Problem-based learning is a student-centered approach that empowers students to conduct research, integrate theory and practice, as well as apply relevant knowledge and skills in generating viable solutions to specific problems [26]. This approach is aimed at improving knowledge and problem-solving skills through authentic and unstructured engagements [6] designed to aid the development of critical thinking and problem-solving skills [27].

Problem-based methods contribute significantly to learning, in terms of developing academic abilities. Students are also promoted to be proactive, foster independent learning behavior, and embrace full responsibility for their learning process [28]. These models allow for teamwork, promote curiosity and collaboration, as well as enforce students' participation [14]. Furthermore, problem-based learning is used to recognize, respond and solve problems, while developing critical thinking skills [14]. In completing problem-based learning tasks, a wide range of skills is necessary, including advanced problem-solving, critical thinking, and effective collaboration [6]. The use of various kinds of intelligence in confronting real-world challenges and the ability to tackle new and existing complexities, tend to increase motivation [29]. The problem-based approach emphasizes the significant role of students in the learning process, where there is a need to construct personal knowledge and not merely the direct use of information [30]. Furthermore, the learning format involves small groups of students in dealing with real problems under lecturers' guidance [31]. The lecturer or tutor facilitates discussion groups to gain knowledge, better understand the problem and explore problem-solving skills [22].

B. The Concept of Problem-Based Learning Supported by Information and Communication Technology

Problem-based learning using information and communication technology help to facilitate collaboration, discussion, information exchange among students and with lecturers as well as assist in solving problems and fulfilling knowledge goals [32]. Savin coined the term PBLonline for ICT-based applications in problem-based learning. This platform contains text-based teaching materials, learning videos and other resources, including chat rooms, messaging facilities, discussion forums and specific environment for problem-based learning [33]. Furthermore, the four reasons for developing PBLonline, include to provide student support, assist students in developing independence through an online system, facilitate problem-solving ability and build influential online groups.

The success of PBLonline involves three essential stages, such as group creation, organization of learning activities and the facilitation of group interactions [34]. An online approach has the potential to increase the attractiveness, accessibility and effectiveness of problem-based learning by improving student communication, collaboration and independent learning abilities [35]. Online problem-based learning plays several important roles in learning activities, including as a web-based learning application that provides communication media and support collaboration, promotes students to build knowledge, as well as presents teaching materials in various forms, such as text, images and videos, provides motivation and direction for students to collaborate as well as allows students to be oriented to the activities of mutual knowledge development [36].

Problem-based learning is typically applied at higher education levels by integrating physical lecturers once a week, where students employ online problem-based learning applications to complete their projects or other assignments [37]. The combination of conventional and online problem-based learning is expected to complement each other, and not to generally cause overlaps or collisions [38]. Lecturers are also require to maintain control and design activities that promote the active student participation. Several advantages of merging conventional and online problem-based learning were observed, including time flexibility, the ability to fulfill various student needs and diverse learning styles [39]. Additional benefits include the achievement of learning objectives, the change in learning pattern from lecturers to a student-centered approach as well as the balance of learning independence and student motivation [39]. Furthermore, three factors were known to influence the successful implementation of problem-based learning that combines conventional and online structures. These elements include learning design, communication (interaction between students in both physical and virtual environments) and motivation (lecturer's support).

1) Conceptual model design

The conceptual model is a general and abstract theoretical description on current reality, synthesis and research supported by experience or limited data [40]. This approach refers to the characteristics of the learning model, based on Collassion learning [41]. Parts of the implementation aspect comprises learning steps (syntax), reaction principle, as well as social and support systems.

Collassion technique contains learning steps known as syntax Collassion Learning which adapts the structures of Rotgans & Schmidt's [42] and Arend's problem-based models [27], adaptable to the characteristics of information systems analysis and design course with ICT support. These steps include:

Phase 1: Problem Definition

Lecturers assign tasks to students in small groups, where each unit further deliberates on the topic, using basic knowledge and skills, subsequently leading to problem formulation.

Phase 2: Independent Learning

Students actively search for relevant information related to the new problems.

Phase 3: Sharing Initial Findings

Students discuss the flow of the information system possibly designed on the basis of student-generated information. This activity is conducted both within and beyond lecture hours through discussion forums on the Collassion Learning App.

Phase 4: Study in Groups

The group discussions are based on measures in generating information system designs, in accordance with the agreed flow and subsequently evaluating the steps for possible corrects. Group learning is also performed within and beyond lecture hours through discussion forums on the Collassion Learning App.

Phase 5: Presentation

Students present the resulting information system designs for additional inputs from other units, including the lecturer.

Phase 6: Evaluation

Students and their groups evaluate these designs and the accompanying steps, based on inputs from other students and lecturers. Further improvements are implemented and submitted, using the task submission feature.

Each phase of the Collassion Learning syntax tends to impact the lecturer's reaction, also called the Principles of Collassion Learning Reaction. These rules occur as follows:

Phase 1: Problem Definition

Students discuss specific instructional objectives, construct initial knowledge and skills, describe various needs, motivate students to engage in problem-solving activities in the form of information system design, divide students into small groups and provide choices of problems for possible solutions. Students are added to discussion groups in Colassion Learning-App according to their group assignments, with only one access right.

Phase 2: Independent Learning

Students are expected to explore accurate sources in finding information system design solutions, based on users' problems.

Phase 3: Sharing Initial Findings

Students monitor the group interaction both within and outside school hours through discussion forums on the Collassion Learning App and provide direct feedback on the flow of the potential information system.

Phase 4: Group Study

Students observe the course of discussions by learning groups both for discussions within and outside lecture hours through the app and provide direct feedback on the information system design drawings by each unit.

Phase 5: Presentation

Students provide input on each group's information system design. Feedback is provided using the available comment facility in the App.

Phase 6: Evaluation

Students receive information system development activity reports from each group submitted to the App and provides an assessment on the available grade facilities.

Social systems are typically generated using student groups. This research developed a social system called the Social Collassion Learning System, where Phases 3, 4, 5 and 6 require group work. Students are expected to develop problem solving skills by formulating individual ideas, generate discussions, receive direct feedback and respond to questions, comments and reviews. Conversely, lecturers help to facilitate and monitor the group discussion both within and outside school hours through discussion forums on the learning app and provides direct feedback.

The support system consists of the Collassion Learning module, which is equipped with HOTS-based tasks and ICT support that facilitates collaboration and discussion called the Collassion Learning App. This application was developed by combining physical and online problem-based learning models or blended learning, using a mixed model known as Problem Based Collassion Blended. The blended version was adapted from the rotation and flex models, two of the four staker and horn mixed learning models [43] as well as the Syntax Collassion Learning. This blended form is a mixed learning model based on the Collassion Learning syntax comprising six phases. Stages 1 and 5 are conducted on physical mode, while 2, 3, 4 and 6 occur online, with emphasis on collaboration and group discussion. The app is also used by lecturers to provide monitoring and direct feedback at each phase.

Collassion Learning App was built with PHP programming language, also known as Hypertext Preprocessor in a framework called CodeIgniter. This application is used to support the Collassion learning model adapted from a problem-based model with a Computer Support Collaborative Learning approach that combines two of the six collaborative learning techniques, including problem-solving and discussion [44]. Collassion Learning App has three users with different access rights, such as system administrators, the course lecturer and the participating students. This platform provides teaching materials in the form of modules with HOTS-based assignments, teaching materials, and learning videos. The application also allows lecturers to group students into smaller units where the assignments are to solve problems, using the discussion facilities, both text and image-based discussion facilities. Lecturers monitor students' activities and provide direct feedback. Furthermore, the app also contains features that allow the assignment of grades to tasks, including the final semester examination scores and the overall grade.

2) Procedural model design

The procedural model presents guidelines as a solution to a particular problem. This is a verbal approach represented in a diagram form [45]. The procedure required to improve students' high-level thinking skills in information system analysis and design activities is to apply the learning model of the information systems design and analysis course, using Collassion Learning as a whole, which is an integral part of its syntax model. Collassion Learning comprises six phases, with each generating students' reactions called the Principles of Collassion Learning Reaction. This response creates an interaction among students and lecturers, also known as the Collassion Learning Social System. The mechanism is entirely reinforced by the Collassion Learning Support System modules with HOTS-based assignments and facilitated by the Collassion Learning App. Under the right learning model, collaboration and discussion are performed without space and time constraints and lecturers are able to monitor and provide direct feedback. Also, students' high-level thinking skills in system analysis and design activities tend to increase.

3) Validity and effectiveness test

The design of this conceptual and procedural model serves as a reference in designing the physical template. In addition, the support system exists in the form of a Collassion Learning App that provides collaboration and discussion facilities containing teaching videos and learning modules with practice questions, pre-tests, and post-tests. Prior to its implementation, a validity assessment was conducted by experts in instructional designs, materials, media, and information technology, as well as language and communication experts. This was followed by an empirical product feasibility analysis using individual and small group evaluations, where several improvements were observed. Subsequently, the process was continued with a feasibility test and the learning model effectiveness was determined by a field trial involving pre-test and post-test.

The learning model effectiveness was obtained by the results of the product effectiveness test, where the post-test average score attained 81.21, with 82.76% of students completely achieving the specified minimum competency standards. This has increased significantly up to 72.41% from the mean pre-test value which was only at 43.69, with a maximum percentage completion of 6.90%. However, to ascertain the level of difference between the pretest and posttest, a significance test of the difference between both averages was conducted using the t-test. The results showed a significant difference both with a significance level of 0.05. Also, the t-count value was equal to -14,112 with a significance of 0.000, due to a minimal t-count, compared to alpha of 5%. Therefore, a significant difference in student learning outcomes was observed before and after using Collassion Learning. Based on this research, the use of Collassion Learning is believed to increase the learning effectiveness in the information systems analysis and design course. As a consequence, collaboration and discussion processes were conducted without space and time constraints. This is in line with Cress and Ann's statement that the use of technology help to facilitate the collaboration process [23]. In addition, problem-based learning with technology support has the potential to enhance the attractiveness, accessibility and effectiveness of problem-based learning, with improved communication, students' collaboration and independent learning abilities [35].

IV. Conclusions

Collassion Learning allows students to integrate collaboration and discussion processes in solve problems specified in the information systems analysis and design course, without space and time constraints. In addition, the model enables lecturers to monitor and provide direct feedback. This learning approach is further applied in this particular course at other universities and also to modules with similar characteristics.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Dwinita Arwidiyarti developed the main idea of the study, conducted data analysis, and designed the test. Meanwhile, Khaerudin contributed to developing learning models both conceptually and procedurally, and Basuki Wibawa contributed to implementing problem-based learning concepts with the support of information technology. All three authors also approved the final version of this manuscript.

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Dwinita Arwidiyarti is a doctoral candidate in the field of educational technology at Universitas Negeri Jakarta-Indonesia. For the bachelor's and master's degrees obtained in the field of informatics. Currently concerned with research in the field of educational technology, specifically applying informatics in the learning process.

Khaerudin is a doctorate in educational technology at Universitas Negeri Jakarta-Indonesia with expertise in curriculum and educational technology, educational research and evaluation.

Basuki Wibawa is a professor in the field of educational technology at Universitas Negeri Jakarta-Indonesia with expertise in mechanical engineering and educational technology.