Developing Research Competence in Prospective Lecturers of Building Engineering Education through Research-Based Blended Flip Learning (RBBFL) Model

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Abstract – **Research competence is one of the professional skills that lecturers must develop. However, in the digital age, lecturers face challenges regarding research and technology literacy, particularly in digital writing where collaborative solutions are necessary. An effective learning model is required to build this competence. Therefore, this research proposed Research-Based Blended Flip Learning (RBBFL) model designed for conducting reliable and efficient research activities. This model is an integration of research-based, blended and flipped learning. It also adopted a research-based design within the framework of developmental research. The validity of the learning model was assessed using the Aiken V coefficient, and its effectiveness was measured with the N-gain score. The results of the research showed that RBBFL model was classified into three major steps, including independent learning for knowledge acquisition, face-to-face learning to share experiences, and guided learning for self-reflection. In summary, the proposed RBBFL model was reliable and effective for conducting research activities.**

Keywords – **Building engineering education, learning model, Research Based Blended Flip Learning, research competency.**

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1. Introduction

Learning model is a crucial tool for lecturers to transfer knowledge effectively. Consequently, selecting an appropriate model contributes significantly to the success of learning [1]. In this regard, research competence plays a vital role as it provides theoretical knowledge and enables independent learning of scientific and educational sources. Its competence comprises essential components for conducting research activities that align with modern education requirements [3].

Moreover, research competence empowers the ability to apply knowledge to new contexts, allowing the transition of students to become experts rather than merely competent practitioners [4].

To develop research competence, various strategies and models have been used [5], [6], [7], [8], [9], [10], [11]. However, there is still limited information regarding the contexts of research-based learning (RBL) and technology-based learning.

RBL (Research-Based Learning) is a systematic learning activity for students to build their understanding and knowledge through research-based projects and reflections on learning experiences. Students think freely, synthesize knowledge from actual data, and share their knowledge to the public through a variety of channels, including writings, presentations, and exhibitions. RBL is divided into 3 domains, including 1) Contemplative Education (CE), which provides forward-looking perspectives and meaningful anticipation, 2) System Thinking (ST), and 3) Professional Learning Community (PLC) [13]. This learning method aims to develop essential competence such as broad orientation, broad knowledge, systemic/network thinking, divergent thinking, creativity, methodological flexibility, resilience, tolerance of ambiguity, as well as communication skills, teamwork, assertiveness, and responsibility [14], [15].

Furthermore, the stages of RBL include developing questions and hypotheses, using research methodology, and presenting independent work or actively engaging in comprehensive projects [16]. In an educational context, RBL is classified into two steps. First, prospective lecturers engage directly with current empirical results. Second, students' learning is integrated with the ongoing research process [17]. The systematic scheme for research-based problem identification consists of:

1) identifying journals,
2) tracking the progress of research topic,
3) reviewing journals,
4) discussing the results, and
5) formulating research topic [18].

Furthermore, the four phases of RBL are

1) assessing students' initial research ability,
2) introducing research methodology,
3) designing research projects,
4) compiling and presenting research papers [19].

The first exposure phase tends to focus on developing core knowledge across various fields through literature review and skill development. The experiential phase gives hands-on research exposure, whereas the capstone phase concludes with oral and written research presentations, which frequently include projects displays and scientific publications [20]. The learning trajectory in RBL consists of research questions, proposals, data collecting, results, article authoring, and publishing [21].

Blended learning, which blends web-based education with face-to-face education, has been shown to dramatically improve students' research competence and critical thinking skills [22]. The use of Mass Open Online Courses (MOOC) in web-based education promotes self-directed learning, improves digital literacy skills, and allows students to create and assess learning objectives [23]. Blended-learning concepts, particularly online and part-time, can increase students motivation [24]. In addition, flexible blended learning methods and specific learning concepts efficiently address the different requirements and interests of a heterogeneous target group [24]. Blended learning environments promote confidence through enhanced interactivity [25]. Previous analysis [26] found that students-centered blended or hybrid educational methods improved total learning results. Furthermore, blended learning improves learning quality by enabling students' freedom as well as promoting creativity and innovation [27].

Flip classroom is a blended learning strategy in which students watch videos or listen to recorded lectures at home while receiving assignment instructions and topic matter to be discussed further in class sessions.

Lecturers lead group projects or learning activities during these sessions [28]. Flip classroom focuses more on projects-based learning, with teaching materials given through technology-based resources such as videos and recordings, which can improve the quality of journals and articles [29]. In a syntactic flip learning strategy, teaching materials are initially offered as learning videos for home study, while classroom sessions focus on group discussions and assignments, with lecturers serving as a facilitators [30]. Flip classroom, which combines face-to-face, online, and blended methods, improves learning results while promoting students' autonomy and engagement [31]. The usage of videos in this classroom has been proven to improve students satisfaction, practicum performance, academic scores, and engagement [32]. Methodologically, flip classroom improves students' competence and learning satisfaction [33]. Blended flip learning model combines an active and interactive education strategy [34]. As a result, the goal of this research is to create research-based blended flip learning (RBBFL) model that will improve prospective lecturers' research competence.

RBBFL model is founded on the notion of heutagogy perspective, which explains self-directed learning with students taking active roles. This perspective is evidence-based and puts students at the heart of the teaching and learning process. The essence of the perspective is to focus on what and how students want to learn in some learning situations. Lecturers act as a facilitators or help to guide on how the desired learning can occur [35]. Additionally, heutagogy is supported by the assumption of two main philosophies, including humanism and constructivism.

Heutagogy learning process was designed in 3 stages, including:

1) collaborative identification of learning needs and results by students and lecturers, followed by contract agreement,

2) development of challenging tasks by lecturers, to be completed both autonomously and with support as learning progresses,

3) assessment of learning based on agreed-upon results to evaluate achievement [36].

Approvals, facilitation, choices, reviews, ratings, and feedback are all essential components of a heutagogic learning strategy [37], as indicated in Figure 1.

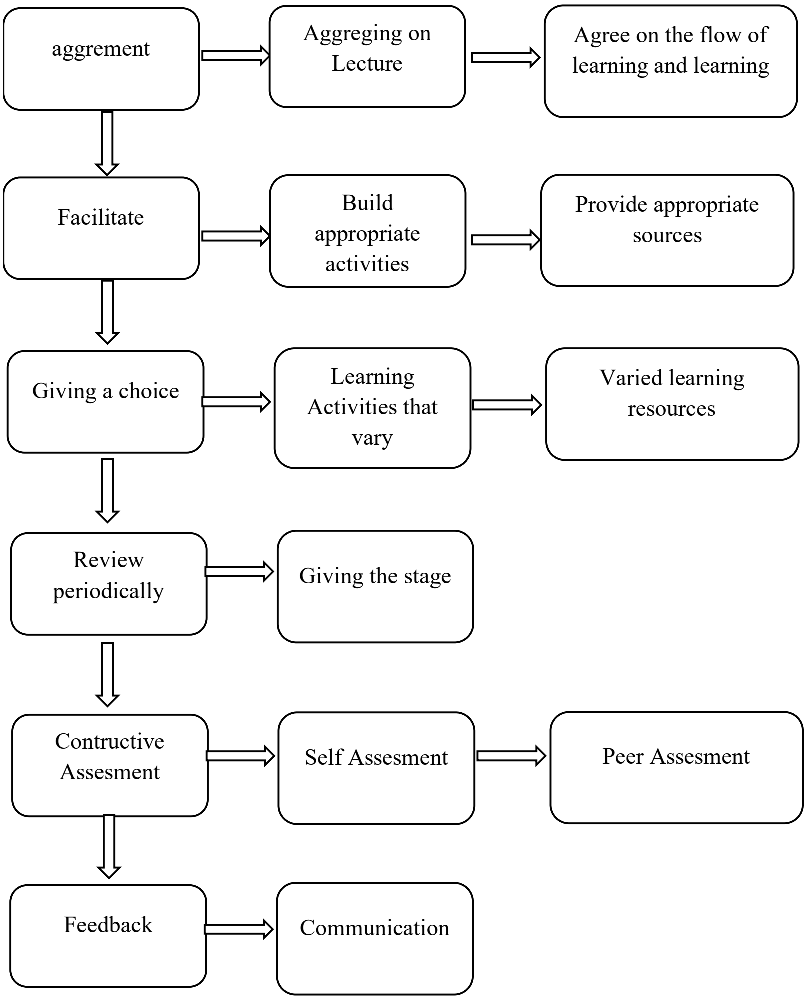

Figure 1. Elements on heutagogy

The objective of this research is to create a learning model in which prospective lecturers participate in research activities, as well as to explain the feasibility of deploying RBBFL. The analysis results indicate that RBBFL model can improve efficiency in RBL.

2. Methodology

The objective of this research was to address learning issues through theoretical and product development. Design-based research (DBR) was adopted as an effort to bridge the theory of education and its application [38], [39], [40]. DBR was carried out collaboratively between academics and practitioners [41], such as research methodology courses lecturers and vocational education specialists. The approach prioritized iterative analysis, design, and assessment to tackle educational challenges. This research used mixed methods in the process of data collection [42]. Interventional investigations including animals or humans, as well as those requiring ethical approval, must identify the authority that provided approval and the corresponding ethical code.

2.1. Research Procedure

The research procedure in Design-based research (DBR) covered 3 stages, including:

1) the analysis-exploration,
2) the design-construction,
3) evaluation-reflection.

These stages were introduced in micro, meso, and macro cycles adapted from the analysis of [43]. The micro-cycle stage was useful for analyzing early research learning with the achievement of prospective lecturers' competence. Meso-cycle stage was useful for designing RBBFL model, while macro-cycle stage was useful for measuring the quality of research competence of prospective lecturers. This analysis assessed the feasibility of several learning methods, focusing on validity and efficacy. The design stage aimed to produce potential solutions to specified challenges, concluding with the creation of RBBFL model that was included in research methodology courses. This research compiled the model feasibility assessment instrument, including input from experts and prospective lecturers regarding research competence.

2.2. Data, Data Sources, Data Retrieval Methods, and Data Analysis

Qualitative data were collected through interviews with 4 lecturers who teach research methodology courses and 11 students from an Indonesian university's building engineering education program. A semi-structured interview was conducted to obtain comprehensive information about learning needs. Before the interview, the respondent was asked for the willingness to be interviewed. The interview was performed both face-to-face and online using Google Meet. To guarantee data reliability and ethical standards, respondents were given the opportunity to check the interview data (member checking) before it was analyzed [44], [45]. The collected data were analyzed using content analysis [46].

Quantitative data were collected from experts' assessments of RBBFL steps in research methodology courses. These evaluations were completed by 11 experts, including educational research experts, linguists, and substance experts with professor and doctorate backgrounds. Data was gathered through surveys with Likert-scale questionnaires and they were validated using the Aiken's V [47]. Additional quantitative data were gathered from 64 students participating in research methodology courses of the building engineering education program. Data were collected using research capability instruments [48]. To compare pre-test and post-test results, data were analyzed using SPSS a paired sample t-tests. The data were considered substantially different when the average pre-test score was less than the average post-test score and the matched sample correlation had a significance value of less than 0.05. This analysis helped to determine the effectiveness of RBBFL model based on the N-gain score. The score was classified as high (> 0.7), medium (0.3-0.7), and low (< 0.7) [49]. The formula for calculating the N-gain score was given in equation 1.

$$N\ Gain = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score} \quad [1]$$

3. Results

This study describes the results obtained at each cycle in every phase of the Design-Based Research (DBR) process.

The cycles include:

(1) analysis and exploration to reveal the needs assessment for developing knowledge in conducting research,

(2) design and construction cycle in the development as well as construction of knowledge for conducting research,

(3) evaluation and reflection cycle in the development as well as construction of knowledge for conducting research.

3.1. Needed Analysis

Interviews with lecturers teaching research methodology courses and students yielded numerous conclusions. Lecturers stressed the need to use technology to navigate results, such as journals databases, detecting plagiarism, doing language checks, writing papers, and others. To improve the competence of teaching research methodology, suggestions included drafting proposals as material for the final project, introducing students to proposal-making applications, and broadening foreign literature. However, various obstacles or shortcomings were discovered, including students frequently copying and pasting from the existing thesis, disregarding plagiarism or Turnitin checks, and becoming ignorant of the percentage of proposals that led to final projects.

From students' perspective, the role of lecturers as a supervisor was essential. Lecturers must help students graduate on time by offering material knowledge, incentives, and assistance. Students identified a range of requirements for learning research methodology, such as teaching materials, motivation, proposal writing precedent, internet access, learning tools, research support applications, ideas for compiling final project proposals, and tips on using book references. The primary goals for students learning research methodology were to apply research methods, understand research steps, understand thesis preparation procedures, solve problems based on events, ensure accountability of research results, understand research types, process data, as well as plan thesis proposals. These requirements directed the development of the learning model.

3.2. Model Design

Researchers created research-based blended flip learning RBBFL model by analyzing the advantages and disadvantages of several research model ideas. This research developed a comprehensive RBBFL paradigm by combining components of RBL research-based learning, blended learning, and flip learning, as shown in Figure 2.

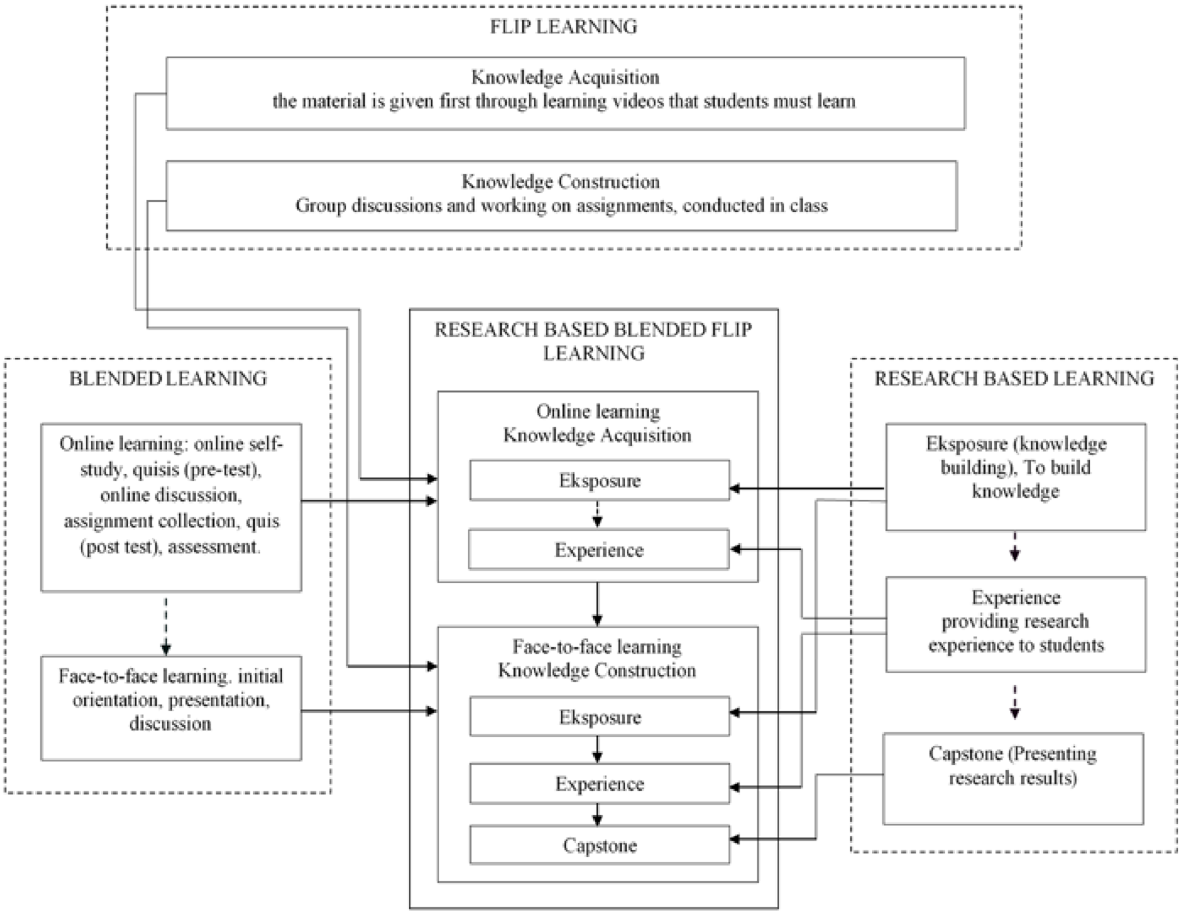

Figure 2. The theoretical framework of RBBFL model

Heutagogy perspective specified each step in RBBFL and this syntactic model had the following structure:

1) In the independent learning stage, to build knowledge (exposure/exploration), students watched educational videos and read educational modules linked to lecturers' material. Finally, students and lecturers reached an agreement on a learning contract (according to heutagogy theory).
2) In the stage of the class meeting, activities for exploring experiences included.
   - Journals analysis activities/other sources (Research question).
   - Lecturers reviewed the material, showed students how to navigate information sources, and gave project possibilities (stage of giving a choice in heutagogy theory). Students then prepared the projects as specified in the contract.
   - Students developed a research plan (Research proposal).
   - Students reviewed projects that have been planned in the agreed contract.
   - Research implementation (Research data). Students collected data for their projects as specified in the contract. Lecturers helped by regularly reviewing progress (the stage of periodically reviewing based on heutagogy theory).
   - Data processing (Research result). Students processed, analyzed, and interpreted in accordance with projects objectives, with lecturers facilitating and reviewing.
   - Writing research results (Result article). According to the contract, students assembled projects results into articles/papers, videos, pictures, and other media. Students self-evaluated their work by checking the plagiarism level (formative assessment stage according to heutagogy).
   - Communicating research results (Research publication /capstone). Students presented the results of their work to friends through presentations and question-answer discussions, as well as conducted a peer assessment (formative assessment stage in heutagogy stage).
   - Feedback. Students collected projects by uploading them to the learning management system. Lecturers then provided conclusions and feedback (the feedback stage was reviewed based on heutagogy theory).
3) Guided learning stages in the context of self-reflection. Lecturers provided feedback on projects assignments uploaded to the learning management system. Students then reflected on such projects, as well as revised and resubmitted (reflection stage in heutagogy stage).

3.3. Expert Validity Test

Approximately 11 experts, including educational research experts, linguists, and substance experts with professor and doctorate backgrounds, validated the learning model.

The methodology was evaluated using 4 indicators, consisting of a learning plan, lecture implementation plan, learning media, and learning evaluation instruments. These indicators were described in 30 model assessment items based on experts' assessment results. Aiken's V was used to compute validity values, which had a threshold of 0.78. According to Table 1, RBBFL model's validation results showed that the V value was greater than the threshold, verifying the validity of all items. As a result, experts committee concluded that RBBFL model was declared feasible for development.

Table 1. RBBFL model validation results

Items	Aiken V value	Statement
1	0.9091	Valid
2	0.9394	Valid
3	0.8788	Valid
4	0.9697	Valid
5	0.8485	Valid
6	0.8485	Valid
7	0.9394	Valid
8	0.7879	Valid
9	0.8485	Valid
10	0.8182	Valid
11	0.8182	Valid
12	0.9091	Valid
13	0.8788	Valid
14	0.8182	Valid
15	0.8182	Valid
16	0.7879	Valid
17	0.7879	Valid
18	0.9091	Valid
19	0.7879	Valid
20	0.9091	Valid
21	0.8788	Valid
22	0.7879	Valid
23	0.8788	Valid
24	0.8788	Valid
25	0.8788	Valid
26	0.7879	Valid
27	0.8788	Valid
28	0.8485	Valid
29	0.8182	Valid
30	0.7879	Valid

3.4. Degree of Effectiveness

RBBFL model's efficacy was examined by comparing students' self-evaluated research competence before and after learning to use it. Research competence was assessed in 5 areas, including: 1) defining the topic and background of research, 2) formulating theoretical foundations, 3) using research methodology, 4) discussing and concluding results, as well as 5) writing published articles.

Table 2. Paired sample statistics

		Mean	*N*	*Std. Deviation*	*Std. Error Mean*
Pair 1	Pre Test	50.00	64	13.729	1.716
	Post Test	67.17	64	12.554	1.569

Table 3. Paired samples correlations

		N	*Correlation*	*Sig.*
Pair 1	Pre-Test & Post-Test	64	0.479	0.000

The results of the data normality test obtained a significance value of < 0.005, indicating that the data was normally distributed. Tables 2 and 3 provided the paired T-test results, showing that the average pre-test value was lower than the average post-test value, with a significance value of < 0.05 suggesting a significant difference between the two tests. The results of the average N-gain value of respondents were shown in Table 4.

Table 4. The N-gain score

Number	Pre-test	Post-test	N Gain Score Percent
1	67	77	30.30
2	43	68	43.86
3	54	82	60.87
4	56	57	2.27
5	54	71	36.96
6	63	71	21.62
7	58	69	26.19
8	60	72	30.00
9	50	66	32.00
10	38	49	17.74
11	71	72	3.45
12	29	49	28.17
13	25	57	42.67
14	56	53	-6.82
15	50	70	40.00
16	51	61	20.41
17	50	82	64.00
18	53	48	-10.64
19	24	38	18.42
20	76	88	50.00
21	29	57	39.44
22	60	69	22.50
23	69	79	32.26
24	51	67	32.65
25	45	70	45.45
26	59	60	2.44
27	46	96	92.59
28	63	72	24.32
29	52	68	33.33
30	48	65	32.69
31	26	90	86.49
32	77	90	56.52
33	76	90	58.33
34	73	81	29.63
35	54	63	19.57
36	41	90	83.05
37	43	72	50.88
38	37	71	53.97
39	26	68	56.76
40	58	62	9.52
41	58	72	33.33
42	24	72	63.16
43	26	35	12.16
44	61	68	17.95
45	65	65	0.00
46	52	57	10.42
47	45	58	23.64
48	52	77	52.08
49	49	52	5.88
50	59	61	4.88
51	54	58	8.70
52	45	69	43.64
53	36	72	56.25
54	56	69	29.55
55	52	72	41.67
56	40	56	26.67
57	39	40	1.64
58	37	57	31.75
59	69	64	-16.13
60	38	69	50.00
61	62	71	23.68
62	39	52	21.31
63	59	80	51.22
64	32	48	23.53

Based on Table 2, the average N-gain score was 31.7, indicating a medium level of effectiveness of the model.

4. Discussion

Target development, material development, implementation, and evaluation benefited from need analysis, which makes it essential for developing an effective learning model [50]. It outlined a clear roadmap for program development and planned workforce augmentation [51]. The achievement of learning objectives was largely determined by the satisfaction of students. Teaching experiences, which included strategies, constraints, and efforts to improve students' research competence, must be equivalent to their learning needs. The facilities offered by lecturers must be matched with the output or learning results anticipated by students. A suitable learning environment that promoted communication, interaction, innovation, and production was critical for acquiring competence [52].

RBBFL model (research-based blended flip learning) combined the theory of RBL, blended learning, and flip learning. The model was valid and effectively used in learning, particularly in research methodology to improve research competence. In the first stage of heutagogical framework, RBBFL began with independent learning, in which students actively build knowledge using video recordings and learning modules [31]. According to heutagogy theory, lecturers support learning by presenting teaching materials through video or modules, followed by collaborative lesson planning with students [37]. This was in line with the results suggesting that supporting learning through mobile devices and social media accessibility improved student-defined learning experiences in an authentic context [53], [54]. Efforts to improve students' experiences, skills, and self-directed learning abilities through teaching activities promoted learning and engagement in social and networking contexts [55]. At this point, flip learning strategy needed students' readiness to participate actively in real-world learning scenarios designed inside the classroom [56].

The second stage consisted of class meetings that promoted experiential learning activities. These activities included establishing a lesson plan prepared for independent learning.

They also comprised journals analysis, topic determination, implementation planning, data collection and analysis, results compilation, writing report materials, and reporting results through presentations and discussions. According to heutagogy theory, this stage focused on periodic review, constructive evaluation, and guided learning [37].

RBL improved research competence by influencing cognitive capabilities [57], enhancing metacognition problem-solving skills [58], and promoting creativity, knowledge, critical thinking, and problem-solving skills [59]. It also promoted pre-service lecturers and higher education professionals to use innovative educational methods [60]. The second meeting was conducted online using mobile learning applications such as Zoom and GMeet. These applications could increase motivation, make learning easier, and become useful [61]. A combination of synchronous activities on Zoom and asynchronous work on Moodle-based LMS platforms improved engineering capabilities [62]. The use of GMeet could maintain an effective learning environment in the online classroom [63]. Through blended learning, students succeeded in academics and increased engagement in learning [64].

The third stage of heutagogical framework was the reflection phase, which focused on guided learning through self-reflection. Lecturers offered feedback on projects assignments, pushing students to consider the assignments they have received [37]. Reflection served as a useful strategy for assessing learning results [65], [12], [2].

The results of the development of RBBFL model, aim to improve research competence of prospective lecturers, specifically in research methodology courses in the building engineering education program showed that this model could be tailored to various fields of study. The use of RBBFL helped students to enhance their research competence. Through the use of flip learning and heutagogy theory, students could also learn independently building research knowledge.

RBBFL model was moderately effective since research competence needed ongoing learning rather than rapid acquisition. Research literacy skills had a considerable influence on the quality of research results. As a result, effective adoption of this model needed lecturers with excellent research competence and high students' literacy ability

5. Conclusion

The Research-Based Blended Flipped Learning (RBBFL) model is an innovative learning framework to improve research and technology literacy of prospective Building Engineering Education teacher students. This model is designed based on the heutagogy theory with five elements: exploration, creation, collaboration, reflection, and connection. The stages of the RBBFL model include independent learning, face-to-face (online/offline), and guided learning. The implementation of the RBBFL model gradually improves students' research competencies after the second intervention, focusing on research topics, theoretical foundations, and research methods.

The advantages of the RBBFL model lie in its validity (Aiken V > 0.78 and effectiveness gain score 31.7). This model supports the improvement of students' research and writing competencies, such as topic determination, theoretical basis, research methods, and publications. Students' needs for literacy technology are also accommodated, including access to references, mastery of research support applications, and adequate learning time. Theoretically, this model integrates research-based learning, blended learning, and flip learning. Practically, this model improves the abilities of lecturers and students in research, writing, and technology-based research collaboration. For further application, infrastructure support, training, and dissemination strategies such as workshops or conferences are needed. This study provides a basis for adopting and developing similar models in various study programs as needed.

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