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Building an Excellence Research Center Selection Model at the Faculty of Engineering, Diponegoro University

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Abstract
The Faculty of Engineering is one of the 13 faculties owned by Diponegoro University. The number of Faculty of Engineering lecturers with multi-year grants is 159 out of 633 lecturers at Diponegoro University who have multi-year grants (25% of lecturers). However, most of the research is monodisciplinary. As a result, the Faculty of Engineering has only a few excellent groups that have produced innovative products and become core competencies. As a faculty with a vision of "Becoming a Research-Based Excellent Faculty at the International Level in 2024", it is necessary to develop multidisciplinary research capable of producing unique, innovative, practical products known to the broader community. To develop leading research groups, the Faculty of Engineering has reviewed the existing research roadmap to identify potential research groups as leading research. Furthermore, to support the faculty leadership's policy in determining research groups to become research centers of excellence, it is necessary to develop criteria for selecting these superior research groups. Therefore, this research aims to create an evaluation framework for identifying research centers of excellence within the Faculty of Engineering at Diponegoro University. Based on a survey of expert respondents, 22 criteria for selecting leading research were obtained. The development of the assessment system includes multiple phases, such as validating research criteria, identifying the weight of each perspective and criterion, designing the scoring system, calculating the final score, and categorizing or classifying the research groups. After validating the scoring system, the membrane research group achieved a total score of 66.28, placing it in the "Good" category. This result indicates that the research group is a strong contender for being nominated as a center of excellence in research.

Keywords: *excellent research, selection criteria, Analytical Hierarchy Process*

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I. INTRODUCTION

Higher education in the national education system has a strategic role in educating the nation's life and advancing science and technology by paying attention to and implementing humanities values as well as cultivating and empowering the Indonesian people sustainably. Therefore, the academic community of Higher Education has an obligation known as the Tri Dharma of Higher Education. One of the Tri Dharma of Higher Education contains "Research and Community Service" [1].

Diponegoro University possesses 13 faculties, with the Faculty of Engineering being one of them. Out of the 633 lecturers at the university with multi-year grants, 159 are from the Faculty of Engineering, which accounts for 25% of the total lecturers. However, the majority of the research conducted by the faculty is focused on a single discipline. Consequently, the Faculty of Engineering has only a handful of exceptional groups that have developed innovative products and established themselves as core competencies. To support the tri dharma of higher education, research at the Faculty of Engineering, Diponegoro University is expected to develop with the vision of "Becoming a Research-Based Excellent Faculty at the International Level in 2024". Achieving this vision requires the integrity of competent and competitive human resources, developing excellent research as needed, supporting facilities, and good governance.

Leading research is research that becomes a character or core competence that reflects the excellence of an institution, which distinguishes the research of one institution from others and is recognized by the user community, and has requests from partners. Excellent research must respond to the needs and challenges of society and the country in the future and refer to the Research Master Plan (RMP), both institutional and national RMP. Leading research is dynamic and develops according to scientific developments [2].

Therefore, the mission of the Faculty of Engineering is to have a research center of excellence that is known to the outside community, not only having research facilities but also being able to produce superior products. Therefore, in selecting an excellent research group, it is necessary to have valid selection criteria so that the results are as expected. Currently, the Faculty of Engineering has evaluated the research roadmap to select research groups that will be given facilities to become centers of research excellence. In order to establish a research center of excellence within the Faculty of Engineering at Diponegoro University, it is essential to define assessment criteria and create a selection model. This model will serve as a framework for faculty leaders to make informed decisions and policies regarding which research groups to prioritize for support. This study aims to build an assessment model for selecting excellent research centers at the Faculty of Engineering, Diponegoro University.

II. RESEARCH METHODS

2.1. Research Design

This research is a mix of methods that combines descriptive qualitative and quantitative methods. According to [3], qualitative research is a research method based on the philosophy of post positivism, used to examine the conditions of natural objects where the researcher is the key instrument. In comparison, the descriptive method is based more on phenomenological philosophy, which prioritizes appreciation (verstehen). Quantitative research in this research report calculates the questionnaire for the results the respondents have filled out. Calculations on the results of the data obtained from the answers to the list of questions in the questionnaire were carried out to obtain supporting data in the study.

In this study, the qualitative method was in the form of descriptions or explanations of the criteria used to assess research fields in the Faculty of Engineering which would then be used as a reference in selecting excellent research in the Faculty of Engineering. Data collection in this study was carried out using open interview methods. The in-depth interview method was chosen to dig deeper into the variables used in the research with experts. With this method, researchers can obtain more detailed information, have a high degree of control in interviews, and gain flexibility in dealing with existing situations. Data collection in this study was carried out using a survey method through a questionnaire with closed questions. The questionnaire method was chosen because the time needed to collect data will be shorter and can provide valid results. The sampling technique used is Judgment Sampling or Purposive Sampling. The research respondents were the Dean and Deputy Dean of the Faculty of Engineering Innovation, the Head of the UNDIP Research and Community Service Institute, and the Head of the Engineering Faculty Research and Community Service Unit. The reason for selecting respondents is that all four are policymakers at the faculty level and managers of research and community services at the University and Faculty levels. They became respondents in validating criteria using the Delphi method and weighting criteria using the AHP method [4].

2.2. Identification of Research Criteria

There are four dimensions and several criteria adapted from the Guidelines for Centers for Excellence in Science and Technology, namely Sourcing/Absorptive Capacity, R&D Capacity, Disseminating Capacity, and Local Resource based [5], and several criteria from the indicators used to assess the research capacity of Faculty of Engineering from the aspect of sustainability of research [6]. The operational definition of each dimension is presented in Table 1.

Table 1 Perspective Research Variable

Concept (Perspective): *Sourcing/Absorptive Capacity*				
Operational Definition: Ability to absorb information and technology from outside: the ability to access technical information, efficiently use existing resources, and prevent research overlap [5]				
No	**Code**	**Dimension (KPI)**	**Operational Definition**	**Ref.**
1	A1	Number of Lecturers with Doctoral degree	The achievement of this lecturer is intended so that the institution has substantial supporting resources in terms of quantity and quality of expertise by the particular focus being developed.	[5]
2	A2	Infrastructure	Includes those that support research and non-research activities according to the focus of the institution's excellence.	[5]
3	A3	Information access	The availability of website media in strengthening branding focuses on excellence and increases the breadth of data and information networks.	[5]
4	A4	Invitation to be a Speaker at an International Conference	Invitations Become keynote speakers - invited speakers who speak in a series of international conference agendas (in plenary sessions)	[5]
5	A5	Invitation to be an International Speaker	Invitation to be a speaker who speaks at a series of international conferences	[5]

6	A6	Visiting of International Institutions to the Science and Technology Center of Excellence	Visits from international institutions as proof of trust and potential for non-research collaboration show that R&D institutions are a reference for special focuses on being developed.	[5]
Concept (Perspective): R&D Capacity				
Operational Definition: Ability to carry out R&D activities: the ability to increase science and technology capacity through the potential for adoption, adaptation, and technology development to increase the competitiveness of goods and/or services through optimizing industrial inputs, processes, and management [5]				
No	**Code**	**Dimension (KPI)**	**Operational Definition**	**Ref.**
7	R1	Roadmap utilization rate	Utilization of the roadmap is implemented in the field in order to achieve the performance of R&D institutions	[5]
8	R2	Patent enhancement strategy and IPR regime	Strategies and implementation in obtaining patents and other IPR regimes need to be prepared in clear and measurable stages	[5]
9	R3	Product Strengthening Strategy based on excellent research	Formulation and implementation of strategies in strengthening superior products through strengthening prototypes so that they are more ready for the downstream process	[5]
10	R4	Strategy to increase Cooperation Utilization of research products	Strategies and implementation stages for the use of superior research-based products through collaboration with other institutions (including industry)	[5]
11	R5	Indexed international journal publications	Publication of research activities in indexed international scientific journals	[5]
12	R6	Accredited national journal publication	Publication of his research activities in accredited national scientific journals	[5]
13	R7	Doctoral graduates produced according to the Center for Excellence in Research Theme	Several doctoral graduates conduct research in the context of their final project at institutions and are guided by researchers at R&D institutions	[5]
14	R8	Acquisition of Patents and IPR	Acquisition figures for patents or IPR regimes	[5]
15	R9	Number of research titles with internal funding	Acquisition figures for research results funded by internal funds	[6]
16	R10	Total internal funding for research	Acquisition figures for the number of internal funding allocations for research	[6]
17	R11	Number of research titles with national funding	Acquisition figures for the number of research titles funded by national funding	[6]
18	R12	Total national funding for research	Acquisition figures for the number of national funding allocations for research	[6]
Concept (Perspective): Disseminating Capacity				
Operational Definition: The ability of the R & D Institute to downstream the results of its benefits is felt by technology users (society, industry, government) [5]				
No	**Code**	**Dimension (KPI)**	**Operational Definition**	**Ref.**
19	D1	Database development strategy and product information	The database and information are used to strengthen the features on the website as an internal "entry point," strengthening the positioning of R&D institutions.	[5]
20	D2	Product downstream mechanism strategy	Includes research and non-research collaborations that utilize the institution's superior products (goods or services). The downstream mechanism will significantly depend on the characteristics of the institution both in the R&D position of Non-Ministry Government Institutions (NMGI) and Ministry Government Institutions (MGI).	[5]
21	D3	National research collaboration	Research collaboration at the national level, whether carried out with higher education R&D, NMGI-MGI government R&D or national industrial R&D.	[5]
22	D4	International research collaboration	Research collaboration at the international level, whether carried out with international university R&D, other government R&D, or international industrial R&D.	[5]
23	D5	Non-research collaboration	The non-research collaboration includes consulting services, education – training, mentoring, technical assistance, and other related services.	[5]
24	D6	Business contract	The downstream of superior products is realized in business contracts with industry or other user parties, which can be in the form of utilizing goods, products, or services developed by R&D institutions.	[5]
25	D7	National recognition appreciation	Outcome – impact in the form of appreciation for national recognition as an R&D institution whose superior products are unique-specific, superior in their fields, and are products that have national and international competitiveness.	[5]
26	D8	Appreciation of National References	The number of non-research collaborations in specific groups of the institution's superior products and recognition of other references	[5]

27	D9	Economic benefits and social impacts	Economic benefits include increasing the regional-national economy and creating social impacts for the user community.	[5]

III. RESULTS AND ANALYSIS

3.1. Research Criteria Validation

The research was conducted at the Faculty of Engineering, Diponegoro University, Semarang. In addition, research is conducted in each department. The research aims to identify inter-scientific linkages between departments, research facilities, and experts for each research topic. Identification of criteria is made by sorting out the indicators used to assess the performance of the Center for Research Excellence [5], as well as the indicators used to assess the research capacity of engineering faculties in the aspect of sustainability of research [6]. Furthermore, later criteria validation was carried out by the Head of the Faculty of Engineering and the Research Institute & Community Service Head. The validation of these criteria uses the Delphi method. Stage I is validating the criteria proposed to several respondents, and stage II is the determination of the characteristics of the assessment criteria for each Likert scale score. The criteria validation process (stage I) used a closed questionnaire with a Likert scale. In stage II, summarizing the results of the previous questionnaire and characterizing the criteria according to the Likert scale [7]. Criteria that have a value of less than four will be eliminated.

Based on the calculation of the mean, it is known that five criteria are eliminated (score less than 4), namely Invitation to be a Speaker at an International Conference (3.75); Invitation to become International Speakers (3.75); Visits of International Institutions to Science and Technology Centers of Excellence (3.5); Doctoral graduates produced according to the Institute's Leading Research Theme (3.75); and Acquiring National References appreciation (3.75). Therefore, these criteria were not used in this study. The reasons for the rejection of these criteria are as follows.

First (criteria A4 and A5), the invitation to be a speaker at an international conference and an international speaker is considered inappropriate because it is not a research key performance indicator (KPI). Research KPI is the number of published results in reputable international and national accredited journals.

Second (criteria A6), visiting international institutions to the science and technology center of excellence is inappropriate because the criteria are not KPIs for research centers. This criterion is a standard for Research Universities abroad and has yet to become an indicator in Indonesia, so it is unsuitable for the Faculty of Engineering.

Third (criteria R7), Doctoral graduates produced according to the theme of the Center for Excellence in Research (CER) are not suitable for use in the Faculty of Engineering because, in practice, CER only functions as a research center and does not provide student guidance or provide minor courses related to the research centers. The Indonesian government, especially Diponegoro University, independently provides research grants for doctoral and master students. However, the application for the grant goes through the promoter, not the CER.

Fourth (criteria D8): national references and appreciation for R&D performance are not appropriate because, according to respondents, this criterion is more suitable for R&D institutions or faculties with several research centers of excellence.

3.2. Determination of the Weight of Each Perspective and Criterion

In the next stage, weight calculations for selected perspectives and criteria are carried out using the pairwise comparison method. The respondents involved were the same as in the previous stage. This stage aims to determine the level of importance of perspective and criteria in the assessment system for determining excellent research centers in the Faculty of Engineering. After getting the respondent's assessment using the pairwise comparison method, calculate the consistency index (CI) using expert choice. If the inconsistency ratio is less than or equal to 10%, then the data obtained is valid.

The Analytical Hierarchy Process (AHP) method in this study was used to determine the weight of each perspective and criteria with the help of Software Expert Choice v.11. In the first stage, building a hierarchical structure consisting of common goals, perspectives, and criteria. Based on the hierarchical structure, there are three perspectives: sourcing absorptive capacity, R&D Capacity, and disseminating capacity. The sourcing absorptive capacity perspective consists of 3 criteria, the R&D Capacity perspective consists of 11 criteria, and the disseminating capacity perspective consists of 8 criteria (Figure 1). The next stage is making a questionnaire in the form of a pairwise comparison matrix. The weighting process consists of 3 stages: distributing questionnaires, checking the consistency ratio, and calculating relative weights.

3.3. Scoring System Design

The scoring system in the rating system was developed using a rating scale. The scoring system is compiled based on a minimum standard development questionnaire validated by the policy maker (the Dean).

This description of the rating scale was adopted and modified from a paper entitled "Ranking the Indicators of building performance and the Users' Risk via the Analytical Hierarchy Process (AHP): Case of Malaysia" [8]. Determination of scores with a rating scale using a scale of 5, namely scores 1, 2, 3, 4, 5. Each of these scores has characteristics or achievement limits. In this study, the achievement limits were divided into two types, the achievement limits for qualitative criteria and the achievement limits for quantitative criteria. An example of a qualitative criterion is a strategy that is difficult to measure quantitatively, so it is necessary to develop a guideline/rubric to determine the score.

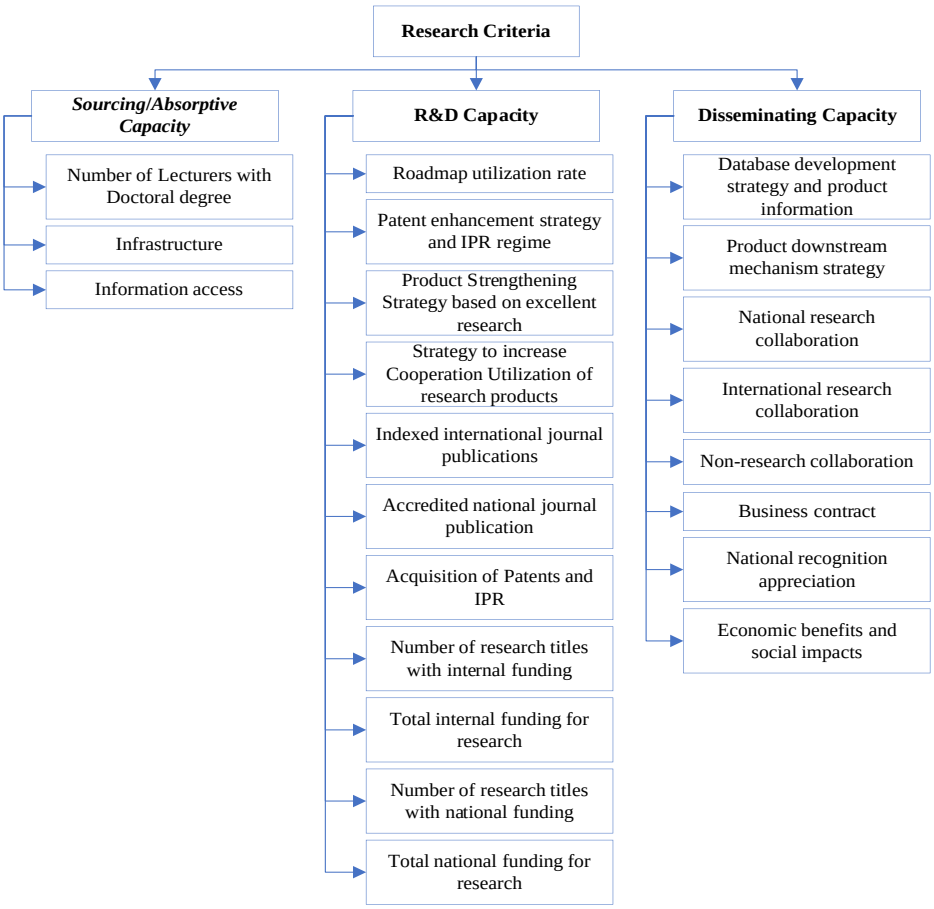

Figure 1 Selected Assessment Criteria

The limitations of qualitative results are obtained from the results of setting a minimum standard on five score scales (1-5), each of which describes its achievements. Quantitative criteria achievement limits are obtained from historical data from the Faculty of Engineering research which have been clustered based on a hierarchical approach. Research clustering is based on the recapitulation of research data and the Faculty of Engineering results. Clustering results are grouped into five score scales. Grouping is done by dividing the scale into 20 intervals (the maximum value is 100 divided by five scales). The minimum target for each criterion will be worth four (good category), except the criteria for international research collaboration and business contracts have a minimum target of 1 each. The scoring rubric/guidance for qualitative outcomes is shown in Table 2. Meanwhile, for quantitative outcomes using historical data mapping on a scale of 5, as previously explained.

Table 2 Scoring rubric/guidance for qualitative outcomes

No	Criteria	Score				
		1	2	3	4	5
1	Infrastructure	No infrastructure yet	Infrastructure available	The infrastructure has been utilized	Utilization of infrastructure according to SOP	Maximum infrastructure utilization
2	Information Access	No access to information yet	Have limited access to information	Access to information has not been utilized	Access to information has been exploited	Maximum utilization of access to information
3	Roadmap utilization rate	There is no roadmap yet.	There is already a roadmap.	There has been no regular review of the roadmap.	The roadmap is reviewed and utilized, but many obstacles exist.	Utilization of the roadmap continues to increase, and there are a few obstacles.
4	Patent enhancement strategy and IPR regime	There is no upgrade strategy yet	There is already an improvement strategy, but not yet structured	There is a review of the root causes of the strategy formulation	There is a review of the root causes and phases of activities in developing the strategy	There is a review of the root causes and activity phases, as well as clear performance baselines and implementation targets in the preparation of the strategy
5	Product Strengthening Strategy based on excellent research	There is no upgrade strategy yet	There is already an improvement strategy, but not yet structured	There is a review of the root causes of the strategy formulation	There is a review of the root causes and phases of activities in developing the strategy	There is a review of the root causes and activity phases, as well as clear performance baselines and implementation targets in the preparation of the strategy
6	Strategy to increase Cooperation Utilization of research products	There is no upgrade strategy yet	There is already an improvement strategy, but not yet structured	There is a review of the root causes of the strategy formulation	There is a review of the root causes and phases of activities in developing the strategy	There is a review of the root causes and activity phases, as well as clear performance baselines and implementation targets in the preparation of the strategy
7	Database development strategy and product information	There is no upgrade strategy yet	There is already an improvement strategy, but not yet structured	There is a review of the root causes of the strategy formulation	There is a review of the root causes and phases of activities in developing the strategy	There is a review of the root causes and activity phases, as well as clear performance baselines and implementation targets in the preparation of the strategy
8	Product downstream mechanism strategy	There is no upgrade strategy yet	There is already an improvement strategy, but not yet structured	There is a review of the root causes of the strategy formulation	There is a review of the root causes and phases of activities in developing the strategy	There is a review of the root causes and activity phases, as well as clear performance baselines and implementation targets in the preparation of the strategy
9	National recognition appreciation	No product yet	Produce products	Produce innovative products	Innovative products are known at the national level	Innovative products recognized at the national level
10	Economic benefit and social impact	Produce innovative products	Produce innovative products but have not made an impact	Produce innovative products, and have a social impact	Producing innovative products that have social impacts and economic benefits	Producing innovative products, having social impacts and economic benefits, and is documented

3.4. Assessment System Design

This Assessment System was adopted, modified according to [8], and adapted to the AHP hierarchy. The assessment consists of several stages, namely evaluating the achievements of the research centers, determining the score for each criterion, calculating the weighted score for each perspective and criterion, and calculating the

assessment. Furthermore, the total score is compared with the achievement level table to include the research centers at a certain level. The assessment system consists of several stages, namely:

1. Evaluation of research achievements

An assessment questionnaire has been developed as a tool for carrying out the evaluation process. Evaluation is carried out on the achievements of each research cluster in the Faculty of Engineering. In addition, the faculty research and community service coordinator has carried out research clustering. Evaluation is carried out in a measurable manner and under the minimum standards set for each qualitative criterion.

2. Determination of the score for each criterion

Then, each criterion is given an achievement score using an assessment scoring scale. The score consists of 5 scales (1-5), which are the results of stage 1.

3. Calculation of weighted scores for each criterion

The scoring results are then multiplied by the weight of each criterion to obtain the weighted score for each criterion.

$$\textit{Criteria weighted score} = \textit{score} \times \textit{criteria weight} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

4. Calculation of weighted scores for each Perspective

The perspective-weighted score is obtained from the calculation of the total weighted score in one perspective multiplied by the perspective weight.

$$\textit{Perspective weighted score} = \sum \textit{criteria weighted score x perspective weighted} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

5. Calculation of Final Score

The total score is obtained from the sum of all weighted scores for each perspective divided by five and then multiplied by 100

$$Total\ Score = \frac{\sum perspective\ weighted\ score}{5} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

6. Categorization or classification

The final step in assessing the research groups is to determine the classification/category of the achievement assessment results. The classification consists of 5 categories, namely: "Very Good," "Good," "Moderate," "Bad," and "Very Bad." The final assessment classification must help assessors (policymakers) decide and determine policies regarding establishing an institutional center of excellence in the Faculty of Engineering. Thus, the results of this assessment can assist Faculty leaders in planning a policy for developing research excellence to become an institution's center of excellence. Classification of Assessment Results as shown at Table 3.

Table 3 Classification of Assessment Results

Score Total	Classification
80 – 100	Very Good
60 – 79	Good
41 – 59	Moderate
31 – 41	Bad
20 – 30	Very Bad

A validation process is required to strengthen the proposed assessment tool's reliability and applicability. Validation was carried out through semi-structured interviews (face validity) with experts. Interviews were conducted to obtain expert views on the suitability of implementing the proposed tool [8]. The criteria validation stage is to conduct a simulation assessment of the selected excellent research. In testing this criterion, the chosen research field is the research field on Membranes at the Faculty of Engineering. The assessment used historical data and closed interviews with the Membrane research team. The assessment results in the membrane research field are described in Table 4.

From the results of the evaluation of membrane research, it was in a good category so that the faculty leadership could consider establishing a center of excellence for membranes in the faculty.

Table 4 Assessment of Prospective Research Centers of Excellence at 2017

No	Criteria	Weight	Score					Weighted Score
			1	2	3	4	5	
Sourcing Absorptive Capacity		**0,405**						**1,457**
1	Number of Lecturers with Doctoral degree	0,467		√				0,934
2	Infrastructure	0,324					√	1,620
3	Information access	0,209					√	1,045
R&D Capacity		**0,370**						**1,390**
4	Roadmap utilization rate	0,075					√	0,375
5	Patent enhancement strategy and IPR regime	0,064					√	0,320

6	Product Strengthening Strategy based on excellent research	0,085					√	0,425
7	Strategy to increase Cooperation Utilization of research products	0,075			√			0,225
8	Indexed international journal publications	0,148				√		0,592
9	Accredited national journal publication	0,117					√	0,585
10	Acquisition of Patents and IPR	0,110			√			0,330
11	Number of research titles with internal funding	0,072	√					0,072
12	Total internal funding for research	0,097			√			0,291
13	Number of research titles with national funding	0,073				√		0,292
14	Total national funding for research	0,084			√			0,252
Disseminating Capacity		0,225						**0,466**
15	Database development strategy and product information	0,131	√					0,131
16	Product downstream mechanism strategy	0,121	√					0,121
17	National research collaboration	0,144	√					0,144
18	International research collaboration	0,139	√					0,139
19	Non-research collaboration	0,099					√	0,495
20	Business contract	0,136	√					0,136
21	National recognition appreciation	0,082		√				0,164
22	Economic benefits and social impacts	1,148					√	0,740
Assessment of Prospective Research Centers of Excellence								**66,28**

The results of the assessment show that the strength of the membrane research group lies in the utilization of infrastructure, access to information, and roadmaps that have been utilized to the fullest, strategies for increasing patents and strengthening research-based excellence products have been implemented, and progress has been made in their implementation. In addition, the membrane research group also has many national publications and non-research collaborations. This membrane research group also has economic benefits and already has social impacts in its application.

The membrane research group has several drawbacks, including the number of Ph.D. researchers, when measured using this assessment tool, which still needs to be more significant. In addition, internal research funds still need to be increased to fund all research activities. Nevertheless, based on the assessment, it can be seen that the membrane research group has a total score of 66.28; and fall into the good category.

IV. CONCLUSION

This study uses the Delphi method to validate the assessment criteria for research centers of excellence. Of the 27 criteria submitted to respondents, five criteria had a scale score of less than four or significant value, namely an invitation to be a speaker at an international conference, an invitation to be an international speaker, visiting international institutions to the science and technology center of excellence, doctoral graduates produced according to the center for excellence in research themes, and appreciation of national references. Thus, 22 criteria can be used to assess research groups in the Faculty of Engineering. Furthermore, each perspective and criterion is weighted using the pairwise comparison method to obtain the weight. Based on the calculation results, the sourcing absorptive capacity perspective weights 0.405, the R&D Capacity perspective weights 0.370, and the disseminating capacity perspective weights 0.225.

The assessment system design consists of several stages, namely: research criteria validation, determination of the weight of each perspective and criterion, scoring system design, final score calculation, amd categorization or classification the research groups. The validation of the scoring system in the membrane research group received a total score of 66.28 (the "Good" category), which means that the research group deserves consideration to be proposed as a center of excellence research.

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