A Bibliometric Analysis Performance Assessment of Science Education on Science Process Skill

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Abstract. This study aims to determine a comprehensive performance assessment of science education using peer assessment and self-assessment to measure scientific process skills. The method of writing article through a literature review that was published from 2010 to 2022, descriptive qualitative and bibliometric analysis was used by the Perish 8 and VOS Viewer software, from 1000 articles sourced from journals, books, conferences, proceedings, and other literature that have been screened on Google Scholar and Scopus databases by the Publish and Perish 8 software. Found 340 articles sourced from journals and only 127 articles indexed by Scopus, consisting of 64 articles on Q1, 47 articles on Q2, 12 Articles on Q3 and four articles on Q4 to be used as references for further analysis as a literature review to write this article. The results of the bibliometric study qualitatively found that a comprehensive assessment of performance on science process skills can be assessed through peer assessment and self-assessment. Further analysis with the VOS Viewer application found a relationship between peer assessment and self-assessment of student science process skills.

Keywords: performance assessment; science education; scientific process skills

INTRODUCTION

Performance assessment is a systematic, formal, and evaluative description of the quality of work with specific standards regarding the advantages and disadvantages of students individually and in groups. It is an essential function of human resources in education [1, 2]. Work in any field will eventually go through a work assessment or evaluation process, namely the assessment and the systems used [3]. The purpose of performance appraisal is to provide feedback to students personally and periodically, control student work behaviour, assign or determine awards [4], predict student progress in their education [5, 6], measure learning needs for students, counselling, setting and measure goals [7].

A performance appraisal system includes making better decisions, higher student satisfaction and motivation, and a more substantial commitment to learning so that learning can be more productive [8]. Students will receive an assessment if they can participate, discuss plans and goals, and be assessed based on factors relevant to their work [9]. Practical assessment has five criteria: validity that can be seen from the assessment factors, reliability or consistency of evaluation, discrimination or can distinguish assessment results, bias-free, and relevant or according to learning situations and conditions [10]. Furthermore, [11] suggests that education with a sound performance appraisal system will use it continuously. This process is divided into four phases, namely:

1. Planning, in this phase, teachers and students hold meetings to discuss and set goals, as well as other work-related matters such as competencies, behaviours and work responsibilities that must be possessed.

2. In this phase of learning to achieve the goals that have been set, the role of the teacher as a guide can motivate students to improve their

learning objectives so that learning objectives can be achieved.

3. Measurement, in this phase, the teacher gives a reflection on the tasks that the student has done, and the results of this phase can influence the student in the form of other awards.

4. This phase is a review, which is to reunite teachers and students to provide and discuss student performance results in depth, and at the end of the meeting, the two again create and set goals and tasks for the future.

Performance assessment systems can sometimes run uneventfully. One of the reasons is the absence of a sense of belonging because Students are not involved in the process, so they are not trained, as well as the difference in the credibility of teachers as assessors [12]. On the other hand, subjective factors such as discrimination in the work environment, culture, race, gender, organizational structure, general stereotypes, perceptual distortions, and social behaviour can also influence [13]. For this reason, specific guidelines are needed in using the grading system and providing grade criteria, communicating the importance of performance appraisal to all students, and reviewing the tools or scoring systems used [14]. Effective performance appraisal has accurate measurements, and reinforcement mechanisms, can identify deficiencies, and provides information as feedback to students to improve their learning in the future [15].

For this reason, collaborative project learning-based performance assessment is considered capable of overcoming problems that arise in performance appraisal. This model can be adjusted to the respective parts of the work so that the performance appraisal will be more open, transparent, and fair. It is hoped that this scoring model can also represent a performance appraisal system that is more advanced than other scoring systems [3].

Performance assessment makes it possible to find out the advantages and disadvantages of student performance, and work assessments can be made more detailed to make it easier for the authorities to provide objective evaluations and recommendations. This begs the question, is it the right grading system to assess project-based performance processes collaboratively, and does it have anything to do with science process skills? Review articles using bibliometric analysis with the Perish and VOS Viewer applications tried to provide solutions regarding performance appraisal systems suitable for collaborative project-based learning and their relation to science process skills.

METHOD

The literature search was carried out on the Google Scholar (GS) database using the Perish 8 or Publish Application with the keyword "Performance Assessment, Project base learning, self-assessment, Peer Assessment, and science process skills". The search results were converted into an Excel file and then analyzed descriptively using STATA software. Furthermore, the data was tabulated in graphs and further interpreted using VOS Viewer qualitatively. The screening results selected for further analysis are those from articles indexed by Scopus in quartiles 1 to 4.

RESULTS AND DISCUSSION

Screening using the Perish application on the Google Scholar database found 1000 publication documents from books, journals, conferences and proceedings, and others from 2010 to 2022, as shown in Figure 1.

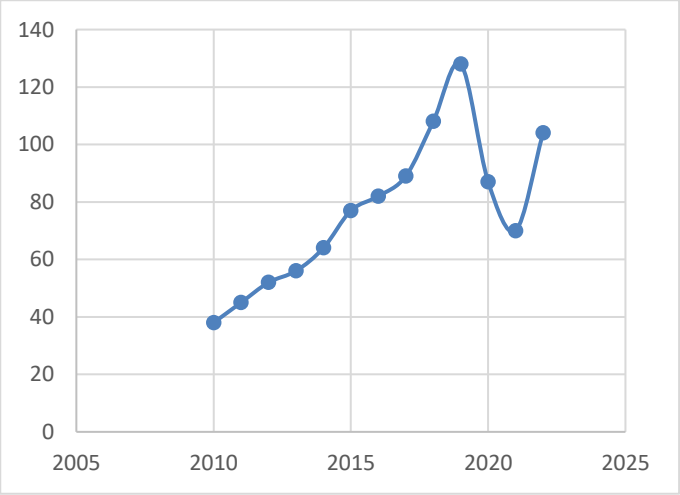

Figure 1 – Publication data using Perish Application Year 2010-2022

Based on Figure 1, from 2010 to 2019, there was a tendency to increase the number of publications related to the topic I wrote about yearly. This means that researchers from various countries consistently research learning assessments related to performance through self-assessment and peers associated with process skills and sci-

ence attitudes. Meanwhile, from 2020 to 2021, there was a decrease in the number of publications related to this research topic due to the impact of COVID-19, which impacted the world of education to conduct research and publish scientific papers. After the completion of the effect of COVID-19, the number of research and publications began to increase again. This can be seen by the increase in magazines in 2022. The search results of 1000 articles (Figure 2) came from 276 articles, 340 journal articles, 298 articles sourced from proceedings and conferences, and sourced from other documents as many as 86 articles.

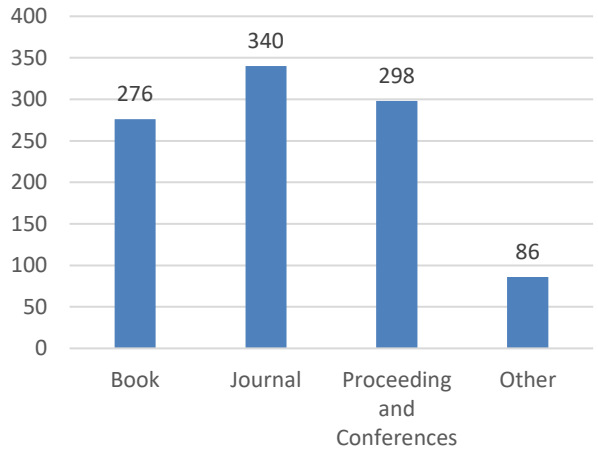

Figure 2 – Article Screening Result using Perish Application

Figure 2 shows that most of the article writing related to this research topic is sourced from journals, namely as many as 340 articles, of the 340 articles based on Figure 3. There are 127 articles indexed by Scopus, 176 articles that are not indexed by Scopus and 37 articles that are duplicates.

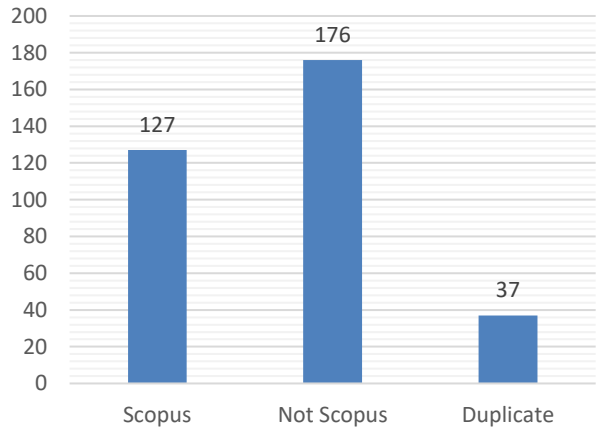

Figure 3 – Indexed the article

Of the 1000 articles screened, the further analysis used in this article is 127 articles indexed by Scopus. Based on Figure 4, it was found that out of 127 papers indexed by Scopus, 64 were in Q1, 47 – in Q2, 12 articles in Q3, and four articles were at the Q4 level. This means that most of the articles used in the advanced analysis in this study were at most in quartile four (Q4).

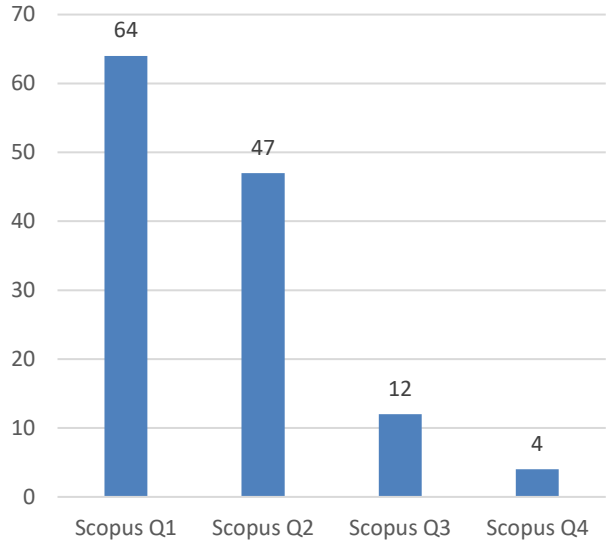

Figure 4 – Article Quartile indexed by Scopus

Based on Vos Viewer's analysis of the keywords of this research topic, obtained in Figure 5. Based on the figure, it can be interpreted that the publication is related to the study of research topics.

Performance Assessment. Based on the learning objectives, assessment activities in the classroom can be grouped into three domains: first, the cognitive realm, which is learning carried out to improve thinking abilities or skills. Second, the goal in the affective realm is to develop attitudes, feelings, and dispositions/personalities. Third, the psychomotor domain, that is, learning to improve skills physically [2]. According to [1], there are two dimensions in the cognitive realm: the knowledge and the mental process dimensions. The level knowledge dimension consists of factual expertise at the lowest level, conceptual understanding and procedural knowledge, and the highest level is meta-cognitive knowledge.

The level of achievement of learning outcomes in the cognitive realm on the dimensions of mental processes, according to [16], consists of remembering as the lowest level, followed by understanding, applying, analyzing, evaluating, and the highest creating. The goals in the affective realm consist of receiving, responding, valuing, organi-

zation and characterization. The plans in the psychomotor domain include readings, observation, perception, response, and adaptation. According to [2], teachers in the physical and the arts, vocational and special education fields should sufficiently consider the purpose of learning in the psychomotor domain. According to [17], there are six levels in this realm: reflex movement, fundamentals (movement patterns that arise from a combination of reflex movements), Perceptual abilities (patterned activities due to instructions), physical abilities (moves and basic abilities needed for complex actions), skilled movements (more complex movements that require a certain level), and nondiscursive communication communicate through body movements).

The development of skill aspects in education receives significant attention. This is because education graduates, primarily vocational, are prepared to enter the world of work directly. This emphasis should be on how the teacher/instructor measures the success of the learning process. Unfortunately, there are still quite a lot of teachers/instructors who use improper assessment instruments. Today the written form test is still dominant enough to measure the level of learning achievement. As a result, graduates' quality in mastering their respective skills is lacking, so they are not absorbed by employment [19].

Assessments require more precise measurement tools to produce correct (valid) measurements. When teaching requires students to create products, carry out procedures or demonstrate physical performance, the most effective form of assessment is an assessment that involves direct observation and assessment activities. This is what is called authentic assessment or often referred to as performance assessment [2, 20].

As for the format or form of class assessment, it is closely related to the purpose of the assessment realm. In the cognitive domain, classroom assessment instruments can be written tests (paper-pencil tests), such as multiple-choice, true-false, matchmaking, and short-answer forms. These forms of written examinations are often called conventional forms of assessment. They are seen as only capable of measuring low cognitive levels and perceived deficiencies to measure ability in higher-level mental aspects. Likewise, these forms of assessment instruments are difficult to measure the achievement of learning outcomes in affective and psychomotor aspects. Measurement of learning outcomes at a higher cognitive level (higher-order thinking), according to [21], requires a task that requires learners to use knowledge and skills in new situations (new or novel situations). Thus, learners are not only necessary to understand but to be able to analyze, evaluate and create [22].

Performance assessment is closely related to the evaluation, self-assessment, and peer assessment to form the ability of science process skills, attitudes of science and critical thinking, and science literacy. This assessment is in line with that conveyed by [18] that performance assessment emphasizes tasks/problems in the evaluation of collaboration oriented to the real world (real world) rather than issues in the context of education. Another form of class assessment is a performance-based [23] or performance assessment [4].

Sometimes people refer to performance assessment as authentic assessment [24] or alternative evaluation [20]. Original means giving meaningful learning tasks [25] to their education. Then this assessment is called alternative because it is another form of paper-and-pencil tests, which are usually in the form of multiple choice or right/wrong choice and are often referred to as response tests [26].

Comprehensive Performance Assessment. Based on Figure 5, the performance assessment process is a complete multidimensional assessment process, and the information obtained from the assessment process should be seen as an integral part of the learning process and inform and empower both students and educators. This aligns with the opinion [14] that the comprehensive assessment model has seven characteristics.

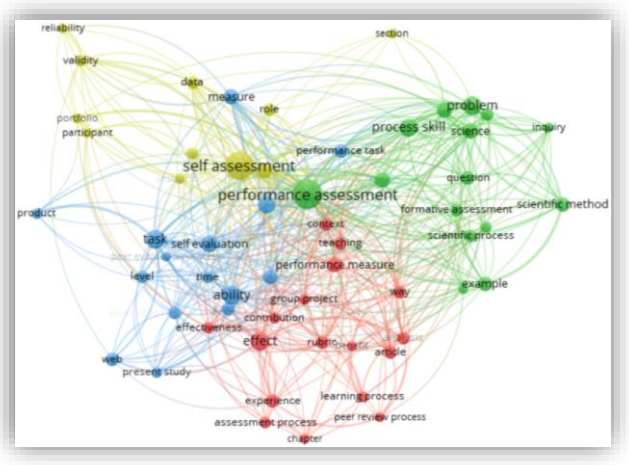

Figure 5 – Comprehensive Performance Assessment using the VOS Viewer Application

First, there is a congruence between philosophical bases, short-term goals, long-term goals, and the assessment instruments used [3, 15]. Second, in the assessment process, students carry out three activities at once, namely selection (sorting), diagnosis (diagnosing), and evaluation [27]. Third, running multiple cutting scores and multiple variables in the selection and diagnosis process, not just a single test/score [28]. Fourth, the assessment instrument simultaneously measures various processes/activities [29]. Fifth, diagnosis and evaluation activities co-occur (ongoing) and cannot be separated in each stage of learning [30]. Sixth, the student diagnoses and evaluates himself, achieving short-term and long-term goals. Seventh, assessments provide practical and pertinent information to improve teaching and inform students [31].

Based on various views and implementation of the assessment and related materials based on Figure 6 above, it can be summarized into an understanding of comprehensive assessment. According to [32], the assessment is comprehensive if:

1) it has some characteristics, including the existence of goal suitability, multilevel, multiple cutting scores and variables, students are involved in the evaluation process, and provide recommendations for teaching improvement;

2) involving various sources of assessment and assessors from different circles;

3) is sustainable so that the assessment results can show the process of competency development;

4) covers various dimensions/areas/domains of assessment.

Especially in vocational practice learning, according to [3], the scope includes reviews on aspects of cognitive skills, work attitudes and behaviours, process skills (work) and products (workpieces).

From a curriculum oriented towards learning materials to mastering competencies bringing demands for changes in the assessment management system. Schools must reorganize and find ways to gather relevant information to rearrange the curriculum and external assessments. According to [5], to be genuinely competency-oriented, there are the following requirements: first, learning is student-oriented, which demands flexibility in the learning process [2, 4]. Second, programs oriented toward work or competence must be developed [5, 7]. Third, schools should differentiate lesson packages into work-domain groups [9]. Fourth, coherence must be organized between the various learning routes within the vocational education system [11]. Fifth, different models of learning and assessment approaches must be developed [13, 14]. Therefore, competency standards-based assessment should be an ontic reflection of field praxis (workplace practice) and standardized in detail so that graduate users know with certainty the competencies/skills possessed by certificate holders [19, 23].

In competency-based learning, it is also essential to pay attention to the achievements of previous competencies through various experiences that students have mastered. [3,7] argues that Recognising Prior Learning (RPL) is critical in implementing competency-based training. What is meant by RPL is a formal procedure in appreciating students' abilities due to their learning and work experiences they have experienced. Many methods can be used to find out the extent of a learner's initial ability level before joining the learning program to be followed. These include 1) interview activities, both structured and unstructured, 2) a review of documentation, 3) product or portfolio assessment, and 4) performance assessment [5-7].

In the competency standards-based learning process, an assessment process is needed that is not only gradual but also able to record achievements in all aspects of learning. According to [17], the emergence of demands for a comprehensive assessment model is because the, first, existing assessment models have not been able to explore complete/comprehensive information on assessment objects [30]. So far, based on scores from product (workpiece) assessments, no/have not been able to explore affective aspects (attitudes and behaviours) and process skills [19]. Second, there is a demand that assessment should be an integral part of the learning process through feedback to students during the practical learning process [4, 6]. A comprehensive assessment plan has been developed by [18] in a health professional preparation program. The implementation of this assessment model is used to assess whether the educational program carried out can meet the demands of the seven areas of responsibility and competencies that entry-level health educators must possess. Strategies adopted in this comprehensive assessment process include focus group inter-

views with senior student participants, department advisory council, assessment by the internship preceptors, interviews with graduating seniors, alum surveys, and portfolio assessment [15]. Thus, according to [21], one of its characteristics is to use diverse strategies and methods (multimethods) and involve various groups as appraisers.

The school designs some assessment programs to meet its various needs, such as to evaluate the level of program accountability, teacher accountability, diagnosis of learning needs, curriculum placement, academic promotion, identification of students' unique needs, and improvement of learning [7,10]. Authors [17] reviewed a comprehensive assessment program that included tests for ongoing assessment of essential ability development from preschool to level 12. These basic skills include reading, math, and language [31, 32].

The components of a comprehensive assessment program that are important to pay attention to are, first, the validity of the content, namely the conformity between the objectives of the test and the objectives of the curriculum [7]. Second, technical ease is seen from the level of reliability of test results [8]. Third, a test result report includes rough scores, correct percentages, local correct percentages, national percentiles, grade equivalents, standard curve equivalents, and equal-interval scores [8]. This report is also supplemented by interpretive statements intended for administrators, teachers, parents, and students [10]. Fourth, the administration is manual clarity in writing and easy-to-follow directions [2]. The physical presentation of the test is well designed, including colour, spacing, and paper thickness, so that it is easy to read and use by students [11].

Referring to [12], three main objectives of assessment cover a wide variety of assessment instruments, both formal and informal, namely as an effort to 1) sort, 2) predict (diagnosing), and 3) evaluate (evaluating). According to [13], placing something in a continuum, the function of selection and placement of an assessment can be in the range between the lowest and highest scores. The process of the diagnosis of an assessment, according to [4], is to collect information about a situation. It can be in the form of strategies, tendencies or processes and feedback in the assessment process (Figure 6). The evaluation function means assessment is a tool used to determine an intervention or treatment that has been carried out on assessment variables, and at the time of the assessment, there is feedback on the course of activities or learning.

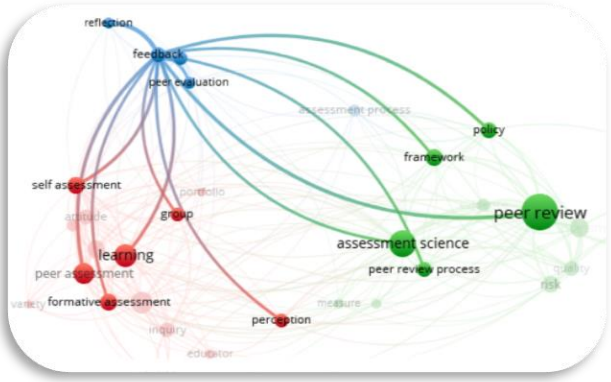

Figure 6 – Feedback at Process Assessment

Project-Based Learning Assessment. The assessment is carried out to assist teachers in measuring the achievement of standards, evaluating each student's progress, providing feedback on the level of understanding that students have achieved, and assisting teachers in developing the next learning strategy [16]. A collaboration project assessment assesses a task that must be completed within a specific time. The study is a series of activities ranging from planning, data collection, organizing, processing, presenting data, and reporting [1,7]. Assessment is the process of collecting and processing information to measure the achievement of learner learning outcomes. The implementation of the assessment refers to the Educational Assessment Standards and other relevant assessment regulations, namely criteria regarding the scope, objectives, benefits, principles, mechanisms, procedures, and instruments for assessing student learning outcomes which are used as a basis for determining student learning outcomes in primary and secondary education.

The project-based learning assessment system analyzed with VIOS viewer is shown in Figure 8. Project-based learning is associated with problems, peer assessment, self-assessment, scientific methods, and their impact on science process skills, attitudes, critical thinking, and science literacy.

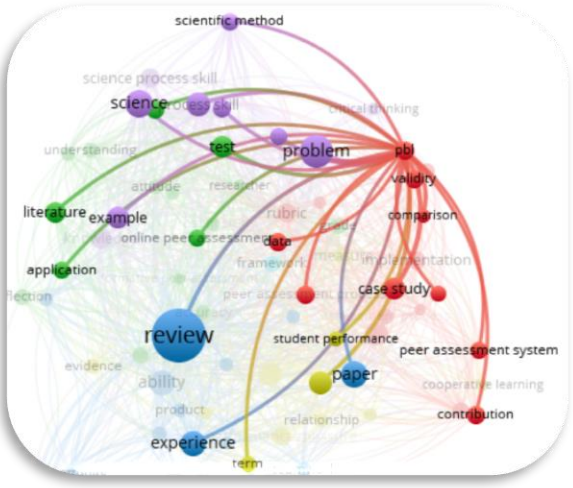

Figure 7 – Project-based learning assessment

Figure 7 above can be implemented in project learning-based assessments in one or more basic competencies [14], can be done on one subject [22], several subjects [20], and clusters of issues are also cross-subjects that are not cognate. According to [6], there are at least four things to consider in the project assessment, namely:

1) Management ability. The ability of students to choose topics, find information, manage data collection time, and write reports carried out in groups [5].

2) Relevance. Conformity of project tasks to subject content, considering the stage of knowledge, understanding, and skills in learning [19].

3) Authenticity. The project carried out by the learner must be the result of his work, taking into account the contribution of the teacher in the form of guidance and support to the project carried out by the student.

4) Innovation and creativity. Projects carried out by students there are elements of novelty (contemporary) and find something unique and different from the usual [20].

Peer Assessment. Assessment is a general term and includes all methods commonly used to determine student learning success by assessing the individual performance of students or groups [17]. Assessment is the application of various means and the use of diverse tools. Based on the results of the VOS Viewer application analysis in Figure 8, shows that peer assessment is related to performance assessment in the form of collaborative projects or groups, self-assessment, science literacy, process skills, critical thinking, science attitudes, and assessment process includes collecting evidence to show learning achievement (competency achievement) of learners [20]. The assessment definition closely relates to each part of the teaching and learning activity. This indicates that the assessment process concerns learning outcomes and all teaching and learning processes [31].

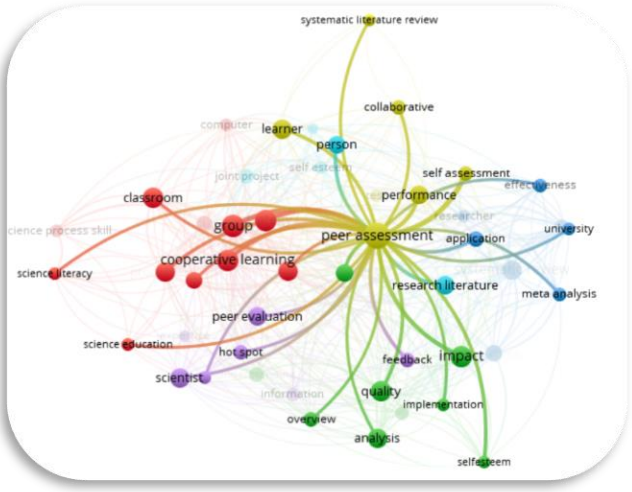

Figure 8 – Peer Assessment Process

According to [17], peer assessment is a process in which a student assesses the learning outcomes of a friend or other student at the same level. Furthermore, [20] stated that peer assessment could be used to assist learners in developing the ability to cooperate, criticize the learning processes and outcomes of others (formative assessment), receive feedback or criticism from others, giving students a deep understanding of the criteria used to assess learning processes and products and for summative assessments. Peer assessment encourages students to have a sense of responsibility for their learning process to be independent, train evaluation skills useful for lifelong learning, and promote deep understanding.

Self Assessment. Based on the VOS Viewer analysis results in Figure 9, self-assessment is associated with performance assessment, peer-to-peer assessment, collaboration assessment, and group assessment to assess itself as related to the status, process, and level of achievement of the competencies it learns [18, 32]. Self-assessment techniques can measure cognitive, affective, and psychomotor competencies [15]. The advantages of using self-assessment in the classroom include:

a) it can foster learners' self-confidence, as they are given the confidence to judge themselves [12];

b) learners are aware of their strengths and weaknesses because when they make an assessment, they must introspect on their strengths and weaknesses [18, 20];

c) can encourage, familiarize, and train learners, to be honest, as they are required to be fair and objective in conducting judgments [19].

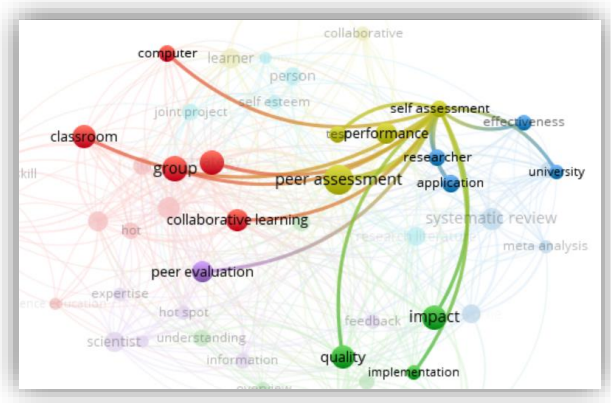

Figure 9 – Self Assessment Process

Self-assessment techniques are carried out based on clear and objective criteria. Therefore, self-assessment by learners in the classroom needs to be carried out through the following steps:

a) Determine the competencies or aspects of assessing the ability [19];

b) Determine the assessment criteria to be used [29];

c) Formulate an assessment format, a scoring guideline, a checklist, or a grading scale [25, 27];

d) Ask learners to conduct a self-assessment [16];

e) review random sample assessment results to encourage students to conduct careful and objective self-assessments [24];

f) Convey feedback to learners based on the results of studies of randomly taken assessment samples [16].

Science Process Skills (SPS). Process skills are needed in learning because it is a vehicle for students to discover and develop facts, concepts, and principles of science. Hence, the position of educators in the learning process is not only as information. According to [20,21], SPS is the ability or ability to act in learning science to produce concepts, theories, principles, laws or facts, or evidence. So SPS is the ability of learners to apply the scientific method in understanding, developing, and discovering science.

Project Collaboration has specific basic skills, namely SPS, which are needed to use science [17, 19]. The SPS of learners can be observed through practicum learning. Observations are carried out before and ongoing until the practicum results are presented. According to [21], SPS learners will be less developed if, in learning, learners tend not to engage with concrete objects. In fact, according to [16], SPS is needed in scientific work because it bases the steps of students on problem-solving, which will ultimately bring the expected abilities.

Furthermore, [18] states that SPS can be developed with the project method because learning with it allows learners to create and practice it. One of the project methods that can be set is Project Based Learning (PjBL). Students' SPS level can be measured by a test, namely using multiple choice test questions that represent all SPS indicators. SPS is defined as an adaptation of the skills used by scientists to compile knowledge, solve problems and have specific basic abilities that are SPS needed to use science [17].

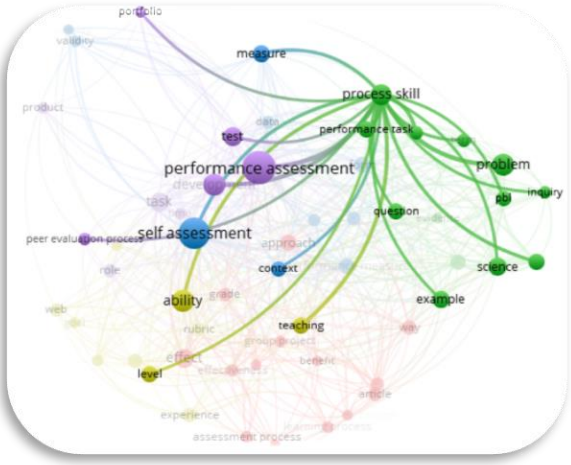

Figure 10 – Science Process Skills

Based on the results of an analysis with the VOS Viewer application regarding science process skills associated with other materials in Figure 10 shows that science process skills are associated with many things, primarily related to the ability to perform, inquiry, problem-based learn-

ing, collaboration, content, context, related to measurements in projects or laboratories, this is in line with what was conveyed by [13] stated that learners' SPS can be observed through practicum learning, made before, are ongoing until the presentation of the results of the practicum. The SPS of the learner will be less developed if the learner tends not to get involved with concrete objects in learning. At the same time, SPS is needed in scientific work because it underlies the steps of learners on problem-solving, which will ultimately bring the expected abilities [10, 13]. SPS can be developed by the project method because learning by the project method gives the learners themselves the opportunity to create and practice it. According to [18], one of the project methods that can be developed is Project Based Learning (PjBL). The SPS level of learners can be measured by a test using multiple choice test questions that represent all SPS indicators [16]. SPS is defined as an adaptation of skills used by scientists to compile knowledge, solve problems, and make learning permanent [20,31].

Meanwhile, according to [17], SPS can also be assessed as a means of understanding and mastering science. It is also the primary purpose of scientific research since skills are needed not only by scientists but by every citizen. Furthermore, [30] stated that SPS is a teaching and learning approach that leads to the growth and development of a certain number of skills in students, to be able to process information or new valuable things in the form of facts, concepts, and the development of attitudes and values.

Learners need to be helped to develop scientific skills, including observing skills, using tools and materials, planning experiments, asking questions, formulating hypotheses conducting experiments, inferring, and communicating findings [11]. Author [15] defines SPS as using several steps to learn as scientists think and work. From this understanding, it can be concluded that SPS is a series of events that students must carry out in seeking and processing the results of their acquisition to become new knowledge for themselves [17]. SPS is essential to be trained and developed. It is a unique knowledge and understanding for students of a concept and theory [18]. The SPS approach must integrate learning scientific work skills as a process of knowledge discovery and formation, learning the basic concepts of scientific knowledge as science content/products, and learning scientific attitudes [30]. Therefore, according to [22], the formation of scientific knowledge begins with the scientific process. Author [14] suggests that SPS can be divided into two groups: basic SPS and integrated SPS.

SPS is the foundation for learning integrated SPS. Basic SPS includes observing, inferring, measuring, communicating, clarifying, and predicting, while what has integrated SPS is controlling variables, providing operational definitions, formulating hypotheses, integrating data, conducting experiments, and formulating models [2].

Thus, it is concluded that science process skills are students' science process skills. Continued by [15] stated the same thing: the influence of project-based learning on science process skills after repeated post-tests. Judging from the research results by [22], project-based learning models can improve learners' science process skills - the ability to act in learning science so that learners produce concepts, theories, and facts.

Based on research that has been conducted by [19] stated that there are differences in learning outcomes of science process skills between groups of students who have field-independent cognitive styles and groups of students who have field-dependent cognitive techniques using the Project Based Learning model. [23] also argues that the results of the study show that there is an influence of Project Based Learning learning on Science Process Skills.

CONCLUSIONS

Comprehensive performance assessment is multidimensional by involving students in the evaluation process. There was feedback and recommendations for teaching improvement, involving various sources and assessment methods as well as assessors from different circles (peer and self-assessment), is sustainable so that the assessment results can show the process of competency development and cover various assessment domains, including assessment on aspects of cognitive skills, attitudes and behaviours, process and product skills of science education.

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