Cyber Physical System vs Learning Factory: Perspective of industry 4.0-based curriculum development

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Abstract. The purpose of this study is to analyze the co-occurrence network of two main keywords in relation to the development of industry 4.0-based curriculum in vocational education. The research method used is bibliometric analysis which can produce information about the most appeared keywords in relation to the main keywords used as input analysis. The search results illustrate that some appeared keywords related to the keywords Cyber Physical System and Learning Factory are then selected into the five highest ranks. The keywords are learning factory which appear twice, industrial revolution 4.0, learning factories, and production system.

1. Introduction
Cyber Physical System (CPS) and learning factory are two important terms that are often associated with discussions about industry 4.0. In the industry 4.0 context the discussion of CPS is also related to the issue of the role of humans in that context, so that the term Human Cyber System (CPS) was born with the concept of Internet-of-People-and-Things [1]. The concept of CPS and its relation to Industry 4.0 also explains the basic principles of CPS operation, including data driven paradigm, real-time performance, and embedded analysis [2,3]. The principle of CPS as a system refers to the integration of cyber computational space and the relationship between computation (intelligence), communication (connectedness), and control (responsiveness) in the three main components of CPS namely cyber, physical, and information systems [4,5].

On the other hand, learning factory is also an inseparable part of the discussion on industry 4.0. Learning factory is learning that can integrate design, manufacturing, and business aspects into the curriculum with an industry driven model [6]. Learning factory is also a learning model that simultaneously describes the learning experience cycle starting from the aspect of developing qualification-research-practice-and-teaching that is oriented to a realistic production environment [7]. Learning factory or often also called learning factories is a characteristic of learning that emphasizes aspects of hands-on learning because students can experience the production process in a holistic manner in an actual work environment [8,9].

The characteristics of CPS and learning factory that are packaged in the context of industry 4.0 are being the focus of this paper. The purpose of this study is to analyze issues related to CPS and Learning Factory which will be used as input for curriculum development in vocational education. The analysis was carried out using Bibliometric Analysis. The principles of learning the production process in the industry (learning factory) with advances in manufacturing that have implemented the CPS concept...
should be taken into consideration for future curriculum development. In this paper we will study the main clusters that can be used as the main points for curriculum development in vocational education.

2. Methods
The study was conducted using a bibliometric analysis approach with a focus on co-word analysis which aims to find out the co-occurrence of keywords that often appear when certain keywords are entered. To sample relevant articles, data searches are performed on a database from Google Scholar, Scopus, and Crossref. The all three are a comprehensive and well-quality peer-reviewed journal database in the world [10]. In this research, the process of data collection is done by using some software, such as PoP ‘Publish or Perish’. This software makes it easy to collect databases from Google Scholar, Scopus, and Crossref [11]. Other software used are Zotero and Mendeley by utilizing plugins in the browser.

An online search was performed on all three data based on May 29th 2020. The keywords entered were "Cyber Physical" AND "Learning Factory" (in Title, Abstract, Keyword). Extract results from the searching are described in the form of visualization using the VOSviewer. From the results of the visualization, the keywords that often appear are then observed which are described with circles ranging from the largest to the smallest (figure 1). Based on the keywords that emerged, the six (6) biggest clusters were taken for the purpose of analysis in this study. The results of sorting 6 keywords/6 clusters are then used as core points for the theoretical foundation of curriculum development in vocational education.

3. Results and discussion
The results of the online search conducted on May 29th 2020 with the keywords "Cyber Physical" AND "Learning Factory" illustrate that there are 35 appeared keywords found on 64 articles.

Figure 1. The keywords co-occurrence network with visualization using VOSviewer.

The appeared keywords in Figure 1 present the data with the 5 biggest circles, namely: Learning Factory, Learning Factory, Industrial Revolution 4.0, Learning Factories, and Production System. The results of
the filtering conceptually will be the material resources to be the key words in curriculum development in vocational education.

3.1. Learning factory / learning factories
Learning factory or some literatures call it learning factories is a learning model to develop future student competencies whose unique characteristics in accordance with the demands of industry 4.0. There are four main components of this learning model that curriculum developers need to consider to formulate future competencies that are relevant to the skills demand in industry 4.0. The particular skills are directly related to aspects of soft skills including scientific process skills-experimentation-creativity-knowledge management (problem solving skills) and self-confidence-management-motivation-regulation-awareness responsibility (metacognitive skills). Both aspects of soft skills need to be integrated in the vocational education curriculum [13].

The concept of learning factory in principle also refers to the concept of industry 4.0 which applies the smart factory principle. Industry 4.0 which must be a reference for the curriculum relevance development in vocational education has main characteristics as smart factory[14-16], smart manufacturing [17], and intelligent factory [18]. The tendency of the future industry with the "smart" characteristics requires vocational education institutions to be able to produce graduates with competencies in accordance with these demands.

3.2. Industrial revolution 4.0
Industry 4.0 in the context of curriculum development will guide the direction and development of curriculum in the future. Implementation of industry 4.0 in learning will provide benefits including being able to develop academic and industrial competence and act as a "bridge" among industry, academy, and professional [19]. Analyzing the characteristics and demands of industry 4.0, experts provide some important references in the process of curriculum development in vocational education, among others, students must be equipped with competencies with the main characteristics namely flexibility, adaptability, and efficiency [20], collaborative and integrative [21]. Students must also be equipped with the ability of self-organization to be able to produce smart products in working conditions of automation and digitalization [18]. In addition, students must own some readiness that can be accommodated into strategies in curriculum development, namely aspects of strategy, culture, technology, and organization [22]. Industry 4.0 is also a system where decision systems are centralized but in the context of information transparency [23].

3.3. Production system
Production system is one of the main characteristics in the industrial 4.0 order with the characteristic of flexibility and self-control which is allegedly a very efficient production model [24]. The flexibility aspect possessed by this system is suitable to be applied in the context of industry 4.0 which is customer-oriented by optimizing flexibility in the aspects of volume, structure, and variants [25]. Industry 4.0 prototype with this production system model has led to the participation of non-human machine operators by applying computational intelligence method [26] and decision support systems with a behavior production system model [27]. This production system needs to be an important concern in the context of learning in vocational education, where the developed curriculum leads to the provision of students’ competencies that have the flexibility and adaptability in accordance with the character of work systems in the industry. This flexibility is important for students to have the ability to work in accordance with the rhythm of rapid change. Adaptability is also necessary in an effort to proactively adapt to new environments.

4. Conclusion
Cyber Physical System and Learning Factory are two very important keywords in the context of understanding the characteristics of industry 4.0. These two concepts are the main keywords to find out a variety of other keywords in implementing the concept of industry 4.0 in the curriculum and learning.
in vocational education. Developing a vocational education curriculum that is relevant to the demands of Industry 4.0 needs to pay attention to aspects of developing soft skills, hard skills, relationships with industry, and models of equipping students who have adequate flexibility and adaptability.

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