Knowledge Management in a Large-Scale Physics Experimental Group Using a Large Collider: A Case Study of the PHENIX Collaboration

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This case study examines the knowledge creation process in an international, large-scale physics experiment group using a large collider, members of which come from various institutes and universities around the world. The research group is called PHENIX, an acronym for the Photon Hadron and Electron in Nuclear Interaction eXperiment, and is based at the Brookhaven National Laboratory in the USA. In the PHENIX Collaboration, there are over 500 scientists from 15 countries at various institutions conducting physics research. However, it is not always clear how to manage large-scale scientific research groups, including how physicists in large experimental groups can publish papers. Furthermore, authorship and credit in a big science group of scientists operate quite differently as compared to a little science group, and there is a hidden cooperative specialization. The precise distribution of roles inside the collaboration is not explicit from outside the collaboration.

Along with the increasing complexity of the collider, an experimental group becomes more organized and systemized. Usually, a high-energy physics paper, which is the result of knowledge creation in a large collaboration, has authors listed in alphabetical order. It is very difficult to find a first author and main contributor in this research field.

This study aims to build a theoretical model of the knowledge creation process in large collider experimental groups from the knowledge management perspective and make practical contributions to large experimental group management. The major research question is "How does the PHENIX with its diverse background members create, share, and utilize knowledge?"

Collected data included official and unofficial documents, e-mails, analysis of self-citations for 140 PHENIX papers and the key paper, and interviews with scientists involved with the PHENIX. To investigate the knowledge creation process of high-energy physics experimental activities by scientists, the author analyzed the knowledge creation processes by paying special attention to the competition and cooperation mode and members' motivation and incentives. Two small case studies are provided: the first is a PHENIX representative paper written by a senior scientist and the second is a paper written by a young scientist. It has been clarified that the Collaboration has established a nine-step process for the creation of scientific papers, including internal review mechanisms.

Four major findings were made. First, it was found that the process of knowledge creation in a large-scale collider experiment is the spiral of the following three phases: *experimenting*, *analyzing*, and *integrating*. Second, the process maintains a balance between competition mode and cooperation mode to produce scientific papers. Third, throughout the process, data is turned into information, and information is converted into knowledge as a scientific paper. Fourth, throughout the process, scientists accumulate and utilize wisdom to create research results.

As a theoretical implication, a model was proposed as a knowledge creation process in a large-scale collider experiment. This model shows organizational knowledge creation through competition and cooperation. It consists of the three phases of *experimenting*, *analyzing*, and *integrating*. This systematic and dynamic model also explains the accumulation and utilization of scientific wisdom.

As for practical implications, this study showed that there is room for improvement in terms of knowledge management, with regards to job mobility among researchers. Some research results were not compiled into a scientific paper because a young scientist who mainly contributed to the data analysis left the collaboration.

Finally, more case studies are needed to examine how big science research groups manage the knowledge creation process and the competition and cooperation modes. Moreover, other big science research group activities should be analyzed to test and improve the theoretical model described above.

Keywords: Sociology of Science, Knowledge Management, Big Science, Authorship and Credit