Interdisciplinary Description of Complex Systems 4(1), 29-43, 2006

SCIENCE AND TEAM DEVELOPMENT

Ralitsa B. Akins[1, *] and Bryan R. Cole[2]

[1]Department of Paediatrics, Texas Tech University Health Sciences Center
El Paso, Texas, United States of America

[2]Department of Educational Administration and Human Resource Development
Texas A&M University
College Station, Texas, United States of America

Regular paper *Received: 13 February*, 2006. *Accepted: 5 May*, 2006.

SUMMARY

This paper explores a new idea about the future development of science and teams, and predicts its possible applications in science, education, workforce development and research. The inter-relatedness of science and teamwork developments suggests a growing importance of team facilitators' quality, as well as the criticality of detailed studies of teamwork processes and team consortiums to address the increasing complexity of exponential knowledge growth and work interdependency.

In the future, it will become much easier to produce a highly specialised workforce, such as brain surgeons or genome engineers, than to identify, educate and develop individuals capable of the delicate and complex work of multi-team facilitation. Such individuals will become the new scientists of the millennium, having extraordinary knowledge in variety of scientific fields, unusual mix of abilities, possessing highly developed interpersonal and teamwork skills, and visionary ideas in illuminating bold strategies for new scientific discoveries. The new scientists of the millennium, through team consortium facilitation, will be able to build bridges between the multitude of diverse and extremely specialised knowledge and interdependent functions to improve systems for the further benefit of mankind.

KEY WORDS

teamwork development, knowledge development, science development, concept development, inter-relatedness of knowledge and science and teamwork

CLASSIFICATION

JEL: Z

*Corresponding author, η: ralitsa_akins@yahoo.com; +1 915 545 6785;
Pediatrics-El Paso, School of Medicine, 4800 Alberta Avenue, El Paso, TX 79905, USA

PURPOSE AND INTENT

The purpose of this paper is to explore a new idea about the development of science and teams, to pictorially present what the science teams of the future might look like, and to predict the possible applications in science, education, workforce development and research.

REVIEW OF KNOWLEDGE ABOUT SCIENCE DEVELOPMENT

Despite the multitude and variety of scientific publications, few address the development of science itself. Among the scientific society, there seems to be no unequivocally accepted theory about emerging knowledge and predicting the direction of new developments.

Two theories have direct implications on our understanding about scientific development. One of them, the theory of scientific revolutions, was developed by Kuhn in the middle of the 20th century. It implies that the scientific society has a very strong commitment to already accepted scientific knowledge, and allows new developments only within the paradigms that rule the scientific disciplines at any given point of time.

The other theory with implications in science development is the Chaos theory. In the early 1960's, Lorentz, a meteorologist, published his observations about the effect of tiny changes in the initial conditions of the system on the end result. His work later became to be known as the Chaos theory.

The development of knowledge and science can be related to the chaos theory, suggesting that scientific development is dependent on the initial state and the dynamics of the system in every scientific field. At any given point of time, the dynamic system of knowledge creation and expansion is trying to become orderly. Although the system's movement from chaos to order, back to chaos and achieving order again seems to be overwhelming, the developments in the system of knowledge at a macro level seem to follow the general rules of any smaller dynamic system with better defined initial conditions. The chaos theory implies that the development in any scientific discipline is defined by the state of other knowledge areas.

These two theories, Kuhn's theory of the nature of scientific revolutions and the chaos theory, are discussed more in depth in the following text. Although addressing science development from a different point of view, each of these theories shows that the development of the body of knowledge in any individual scientific field is dependent on the interactions with other scientific disciplines.

After the discussion of these two theories, the impact of knowledge growth on specialities and sub-specialities development is explored from a historical aspect, as well as in the light of applications of the internal similarities in scientific development and the roles of contemporary scientific paradigms.

KUHN'S THEORY OF SCIENTIFIC REVOLUTIONS

A landmark in intellectual history, Kuhn's book, The structure of scientific revolutions, offered an elegant, clear and in-depth explanation of the process of discovery [1]. Kuhn defined the "normal science" as research based on previous scientific achievements, and intricately grounded in the prevailing scientific paradigms, which defined the accepted models for solving scientific problems.

The scientific community has the vested power to choose between paradigms. The reigning scientific paradigms in any given field of discovery govern the methods of research and ultimately shape the nature of the "legitimate" problems to be studied and resolved by contemporary science. To become part of the scientific community, researchers strive to fit nature processes into the known and shared paradigms, committing to the same rules and standards of scientific discovery.

When an observed event violates the expectation of the ruling paradigm, that area of anomaly attracts researchers' attention; thus, paradigms trace the road for the next discoveries by preparing researchers to recognise and study scientific anomalies. Eloquent and insightful, graciously presenting scientific aphorisms and depicting researchers' mindsets, Kuhn's theory of scientific revolutions suggests that the motor behind scientific discovery lies in the power of scientific paradigms and the bravery and curiosity of individual researchers studying the observed scientific anomalies. Developments in one scientific field open the doors for using the new knowledge in other science disciplines. The nature of scientific development postulates that development of individual scientific fields is dependent on the dynamic interactions with other scientific disciplines.

THE CHAOS THEORY

The field of science is seemingly orderly to the scientific observer. There are scientific disciplines, which study the order (or, rather, strive to provide an acceptable nomenclature) in the development of mankind's knowledge. However, the system of human knowledge is extremely dynamic, with rapid progression and developments, possibly in a state of chaos, and, as other dynamic systems, is struggling to achieve order.

The *Chaos theory* explains the order in seemingly random behaviours in dynamic systems, where the movement never repeats itself but stays within a loop, called the Lorentz attractor [2]. The Lorentz attractor is fractal and displays attributes of self-similarity; however, it is not periodic. The sensitivity of dynamic systems to their initial conditions causes slight differences in the initial parameters to change the state of dynamics, leading to diverging and bifurcating. Therefore, a slight change in the initial system's conditions would yield a different result in time. The chaos theory is also discussed in light of the possible effect of the movement of a butterfly's wings to the weather conditions in time in a different part of the world, an effect known as "the butterfly effect."

Robert May, a biologist experimenting with population growth, discovered that a dynamic system in growth bifurcated soon after the population growth rate passed 3. Instead of settling down to one single population number, the number of the population jumped between 2 different values for each observation period. This bifurcation of the population numbers is reminiscent of the Lorentz attractor [2]. In the May's population growth experiment, the higher the growth rate, the quicker the bifurcations occurred; the population lines bifurcated faster and faster until suddenly, chaos appeared.

Even when a system is in a perfect chaos, there are "windows of order" within that dynamic system, where bifurcations may temporarily occur before that part of the system enters state of chaos again. Feigenbaum determined that the bifurcations in dynamic systems came at a constant rate, calculated as 4,669; thus, discovering the rate of bifurcations' self-similarity [2].

Mathematician B. Mandelbrot was studying the stock prices over time and discovered that the prices did not fit the normal distribution, but the curves for daily and monthly changes matched perfectly over a period of 60 years. Many real-world systems are self-similar, such as the growth of tree leafs, bronchioles in human lungs, blood vessels in mammals, or the stock-market values over time [2]. The development of human knowledge and science follows self-similarity, expanding in any given field under the influence of other scientific fields, and bifurcating (entering new areas of knowledge) when the growth rate of knowledge expands.

HISTORY OF SCIENCE GROWTH

Early science development

In the inception of human discovery, scientists had a holistic approach, studying all fields of the available knowledge, being mathematicians, philosophers, astronomers and people of the arts. The Sophists' practical arts of rhetoric, history, music and mathematics opened opportunities for public careers and success in society. Socrates argued that the purpose of "philosophy" is not the discovery of cosmos, rather finding out how man's life should best be lived. In those first scientific schools, the individual scientist – philosopher, artist and mathematician – was at the centre of scientific development [3].

Gradually, new and more distinct sciences emerged; biology, physics, ethics, politics and other sciences joined the core of logic and mathematics. In the first and second centuries AD, the first known "research centre" was functioning at Alexandria on the Egyptian coast. The body of scientific knowledge had grown significantly and scientists were specialising in astronomy, anatomy, medicine, geography, poetry, grammar, mathematics, natural history, philology, and other disciplines. The Roman emperor Julian in the fourth century AD established specific regulations for the candidates for professorship, requiring the candidates to teach to be approved by the municipal senate. Later, the Cathedral church schools endorsed the mastery of the Seven Liberal Arts (grammar, rhetoric, dialectic, arithmetic, music, geometry and astronomy), claiming that a scholar should be knowledgeable in everything and no knowledge is superfluous [3].

Speciality and sub-speciality development

The abundance of knowledge in each separate scientific field led to further branching of each discipline into sub-disciplines. For example, medicine branched into paediatrics, surgery, internal medicine, pathology, and so on. With the accumulation of new knowledge, each new speciality continued to branch into even more narrowly specialised sub-specialities (e.g., surgery branched into colon and rectal surgery, neurological surgery, orthopedic surgery, plastic surgery, and thoracic surgery). Currently, in the United States there are 24 member boards to the American Board of Medical Specialties (ABMS) [4].

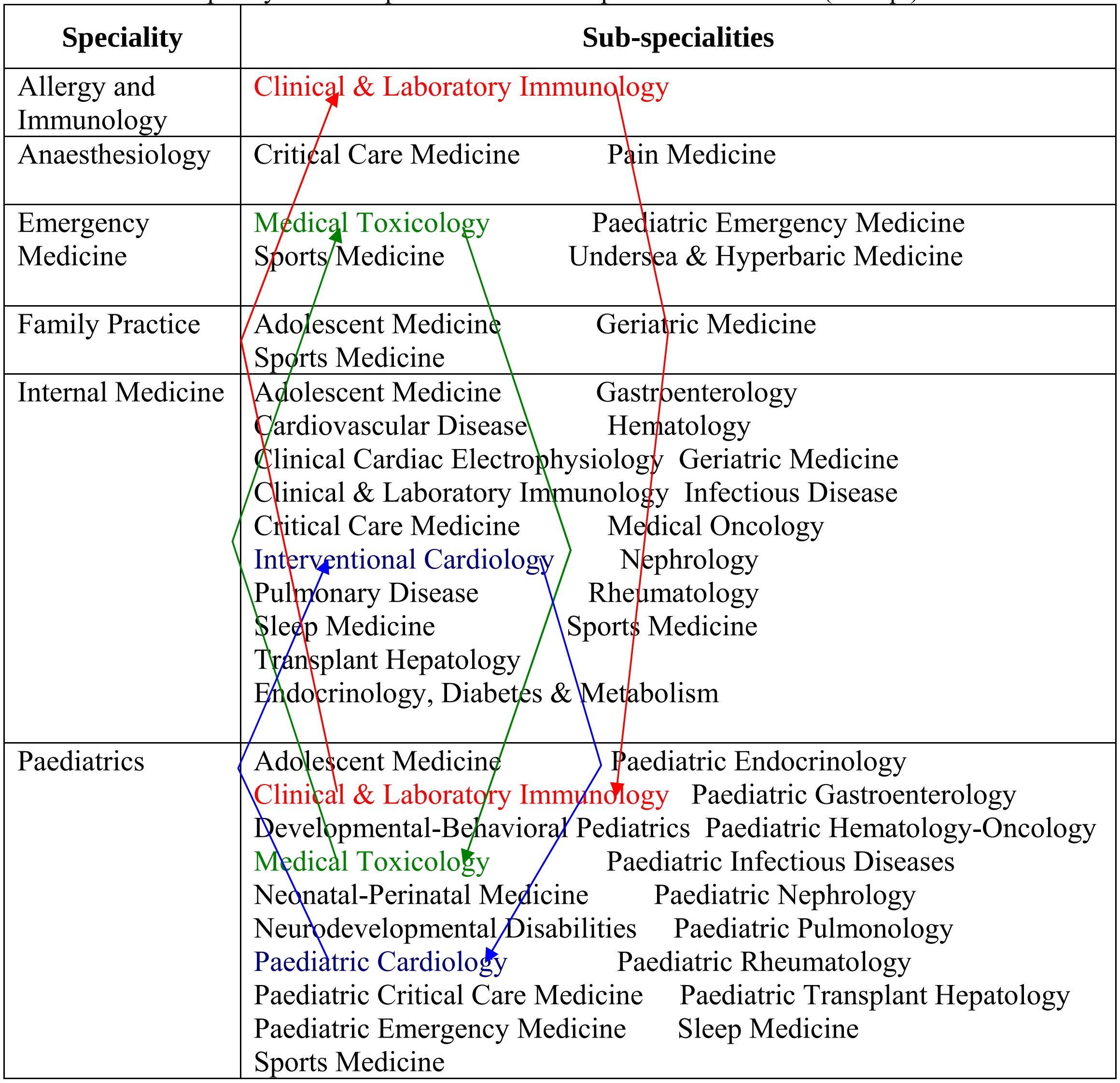
Table 1 presents an excerpt from the US approved specialities and sub-specialities, as available through the ABMS. It is interesting to note that the majority of the medical specialities, while continuing to divide into sub-specialities and further branch, remain within known parameters, defined by the available other specialities.

As shown in Table 1, *paediatrics* has a sub-speciality of *emergency medicine,* which is otherwise a separate speciality. Some of the sub-specialities in paediatrics appear to be common for other specialities. For example, *medical toxicology* is also a sub-speciality in *emergency medicine*, and *clinical and laboratory immunology* is also a sub-speciality in *allergy and immunology*. Likewise, the speciality of *emergency medicine* has *paediatric emergency medicine* as a sub-speciality. Three of these internal relations (loops) between different medical specialities and their sub-specialities are demonstrated on Table 1. Of course, many more exist.

LINKING TOGETHER KUHN'S THEORY AND THE CHAOS THEORY

As demonstrated in Table 1, between-specialities relations form knowledge "internal loops." These "internal loops" of knowledge show self-similarity, as suggested by the *Chaos theory*. The knowledge in one medical discipline expands in interaction with other medical disciplines; thus, knowledge from other areas pertinent to one particular medical field forms a

Table 1. Contemporary medical specialities and sub-specialities in the US (excerpt).



Speciality	Sub-specialities
Allergy and Immunology	Clinical & Laboratory Immunology
Anaesthesiology	Critical Care Medicine Pain Medicine
Emergency Medicine	Medical Toxicology Paediatric Emergency Medicine Sports Medicine Undersea & Hyperbaric Medicine
Family Practice	Adolescent Medicine Geriatric Medicine Sports Medicine
Internal Medicine	Adolescent Medicine Gastroenterology Cardiovascular Disease Hematology Clinical Cardiac Electrophysiology Geriatric Medicine Clinical & Laboratory Immunology Infectious Disease Critical Care Medicine Medical Oncology Interventional Cardiology Nephrology Pulmonary Disease Rheumatology Sleep Medicine Sports Medicine Transplant Hepatology Endocrinology, Diabetes & Metabolism
Paediatrics	Adolescent Medicine Paediatric Endocrinology Clinical & Laboratory Immunology Paediatric Gastroenterology Developmental-Behavioral Pediatrics Paediatric Hematology-Oncology Medical Toxicology Paediatric Infectious Diseases Neonatal-Perinatal Medicine Paediatric Nephrology Neurodevelopmental Disabilities Paediatric Pulmonology Paediatric Cardiology Paediatric Rheumatology Paediatric Critical Care Medicine Paediatric Transplant Hepatology Paediatric Emergency Medicine Sleep Medicine Sports Medicine

sub-speciality for that field. For example, the advancements in understanding of human immunology helped develop a new sub-speciality in paediatrics.

Such "internal loops"/self-similarities in the development of knowledge are also present in other scientific fields (e.g. engineering). Furthermore, such similarities exist in the development of scientific fields in different countries, while some minor differences in the specific science-field branching could be observed.

It is logical to suggest that the development of internal science-field-related similarity sets is dependent on the specific initial set of parameters, influenced by political, educational, economical and other societal rules that possibly interfered with the growth of knowledge and development of science. This all comes at a time when a systems perspective of problem solving is more critical than ever. While disciplines are increasingly sub-specialising, problems are increasingly becoming more complex, and require a multi-disciplinary/cross-functional perspective for effectively addressing them.

The internal similarity in knowledge development is consistent with the *Chaos theory*. Seemingly random developments in diverse scientific fields are interrelated from the perspective of the human knowledge macro-system. Discoveries in one field prompt discoveries in another. For example, the discovery of the X-rays led to the development of new medical diagnostic techniques, better understanding of many diseases, and eventually a new medical speciality, radiology. The development of radiology as a speciality, however, was only possible because of the recognition of the scientific paradigm behind this novelty by the scientific society (consistent with Kuhn's theory of scientific revolutions). Therefore, Kuhn's theory of scientific revolutions, coupled with the *Chaos theory* could possibly explain the overall development of new scientific fields and disciplines.

REVIEW OF CURRENT KNOWLEDGE OF TEAM DEVELOPMENT

Although contemporary science is more likely developed in teams rather than by an individual (e.g. research projects in any given field of medical science), studies of teams and team development are somewhat lagging in understanding of the modern teamwork and the philosophy behind it. Despite the abundance of publications on teamwork, there is a staggering gap in our knowledge about the development of teams and teamwork as a concept. Different types of teams and environments are described and studied but the links between the emerging and development of teams and the evolution of teamwork remain unexplored. In general, scarcity of funding for research on the development and functions of different kinds of teams has been noted [5]. A brief review of the current understanding of teams and teamwork is presented below.

TEAM DEVELOPMENT STAGES

Historically, teams have been viewed as temporary units, which create, function and disintegrate over time. Human teams go through a set of stages in their development (L – defining values, A – acquiring resources, I – assuming roles and G – leadership coordination); however, there is no typical sequence, nor does every team go through every stage. The team development stages are also known as forming, storming, norming, and performing. At the end of the team's life, the group usually deals with matters of termination [6, 7].

ROLE OF THE TEAMWORK ENVIRONMENT

A team's ability to form, function and sustain itself is interrelated to its communication and cooperation with other individuals and groups within the organisation and/or external parties. With the increasing complexity of team make-up or performance tasks, the importance of coordinating, keeping records and tracking progress increases [8].

It has been argued that the multidimensionality of group effectiveness could be determined by 3 criteria: (1) team's productivity, (2) social, intellectual or material rewards to the team members, and (3) sustainability of the team as a social unit over time [9]. More often than not, when performing complex tasks and drawing from different expertise, the team's productivity, gained by the division of labour is decreased by the added lines of communication and the need for coordination [10]. For example, in healthcare, the interdisciplinary health care teamwork is highly dependent not only on diagnosis and management, but also on interpersonal communications. In order to cut costs, a lesser trained workforce is expected to assume greater responsibilities, meaning that interpersonal and team skills may be less developed, thus contributing to fragmented care and opportunities for mistakes [5].

TRANSACTIVE MEMORY IN KNOWLEDGE SHARING

Team members can have different knowledge areas and use one another as external knowledge "storage." By dividing the responsibility for different knowledge expertise, the team members can share knowledge more effectively. When knowledge in a particular area is needed, the team members can communicate (or, have "transactions") with their colleagues and retrieve the needed information. This "transactive memory" is used in team knowledge sharing and improved performance [11 – 13]. Since complex teams have members with diverse background and area of expertise, this collective memory is critical for successful task completion [14]. From an organizational perspective, organizational transactive memory can be technology-supported, assigning knowledge responsibilities within specialized departments and supporting knowledge transfer between individuals from different organizational divisions [15].

FACILITATED COMMUNICATIONS

The role of facilitated communications proves to be an important area of research in light of teamwork. Both human-to-human and human-technology interactions shape the outcome of teamwork. Additionally, facilitator influence in teamwork has proved to be a well-demonstrated phenomenon [16].

Facilitator characteristics

It has been argued that facilitators could, at least in part, determine the outcome in the context of facilitated communications, dependent on their characteristics, attitudes and beliefs. The variability in facilitator influence on the outcomes is due to contextual and attitude factors [16]. Facilitator characteristics, including gender, education, age, years of experience, special training, etc. are usually reported. Specific attributes, such as commanding respect from others, being good communicators, being proactive in making things happen, willing to challenge and having the potential to develop beyond their current role, have been considered as key elements of successful facilitators [17].

Skills in human relations and communications have been consistently reported as crucial in facilitated interactions. McFadzean described five areas of general competencies for facilitators (planning, group dynamics, problem-solving and decision-making, communication, and personal growth and development), and five levels of specific competencies (attention to task, attention to meeting process, attention to team structure, attention to team dynamics, and attention to team trust) [18].

However, there is no consistent body of knowledge about the implications of variable facilitator characteristics. One study [19] reported that facilitators with higher education, training and experience, and facilitators who are older, are less likely to influence the outcome of facilitated communications. Another study [20] noted positive correlation between the amount of facilitator training and (1) learning about group's characteristics and goals, (2) identifying areas of conflict and (3) discussing the use of technology.

Complex teams often need to work across boundaries: departmental, organizational, cultural, language, time or distance. Such boundary-crossing issues could affect teamwork and relationship-building. Awareness about the existence of boundary-crossing issues is essential for complex team facilitators. Boundary-crossing facilitation would require different relationship-building expectations, strategies and selection of communication channels [21]. Therefore, more research on team facilitator characteristics, including training, education and experience, and their influence is needed.

Intellectual teamwork

To understand the intellectual teamwork, which utilises information technology to augment performance, we would need technical expertise and knowledge about the social and behavioural processes that the technology is designed to support [20, 22]. Individuals in intellectual teams are not always together to produce a material outcome; rather, to exchange and manipulate available knowledge and information. Intellectual teams function in a variety of environments and tasks. Utilising communication and cooperation, intellectual teams perform interdisciplinary research, formulate multi-site corporate strategies and decide on medical diagnosis [22]. The intellectual teams have laid the basis for the emergence of "virtual" teams, in which members may or may not have person-to-person contacts and are heavily relying on information technology connectivity and communicability [23].

Collaboration between human and digital facilitators

The information communication technology is rapidly evolving. Embedded intelligent systems can assist in problem recognition and pattern identification, while providing real-time response, information and expertise [24]. While the globalizations and accessibility of electronic communication tools create new opportunities, they also create information overload and additional work in information management [25].

The ability to communicate across the globe has become a requirement for success. Boundary-crossing teams are strongly dependent on electronic channels of communication. Use of telephone, email, videoconferencing and web conferencing allow crossing time and distance barriers. More often than not, team facilitators select the technology they are most familiar with and trust, and which is readily accessible. Issues with digital facilitators include management of the information overload and difficulty in managing cultural perspectives of the teamwork relationships [26]. Cultural differences may determine misinterpretation of electronic communications; therefore, awareness and sensitivity to local cultures are key factors in appropriate relationship building [21].

NEW IDEA ABOUT SCIENCE AND TEAM DEVELOPMENT

The incredible expansion of human knowledge and the increasing complexity of scientific problems demand working in teams and coordination between the timing and tasks each team member accomplishes. Therefore, the developments of science and teamwork can no longer be viewed or studied separately. A new concept about the interrelatedness of science and team development emerges and defining the parameters of a scientific (or, knowledge) unit becomes necessary.

THE IDEA OF SCIENCE UNIT CONTAINMENT IN TEAMWORK DEVELOPMENT

Defining the "science unit"

Centuries ago all or most of the knowledge could be contained by one individual (e.g., ancient philosophers), and the individual was in a sense a self-sufficient "science unit." With the development of science, this became impossible.

Next, all the knowledge in one discipline (e.g., medicine) could be contained by one individual, presenting another type, but still individually self-sufficient "science unit." With the growth of knowledge, this became impossible and specialities developed. For example, in medicine, one individual treated adults and children, performed surgeries and autopsies, and did not send any of his patients to consultations with specialists, simply because specialists did not exist. With the growth of knowledge, specialities and further sub-specialities developed, and the perimeter of activity of the doctor-generalist (e.g. family medicine doctor) started to decrease. The necessity for interactions between and among individual "science units" in order to solve problems and complete tasks started to increase.

The broader, more specialised and in-depth the knowledge of human diseases became, the more restricted the knowledge and types of activities the generalists could perform appeared. Furthermore, with the development of human civilisation, new diseases occurred: diseases which were not previously identified due to knowledge insufficiencies, diseases spread by the growth of travel and migration, or provoked by changes in environment, industries or lifestyles. This interdependence might be another example of an "internal loop" or, could represent a true Mandelbrot similarity set.

Shared knowledge and teamwork

With the globalisation of business, communication and research, the importance of teamwork becomes enormous. Human knowledge development occurs simultaneously in many parts of the world and is shared very quickly by means of information technology. The access to monster-size databases, the possibility for computer simulation modelling, and continued technological advancements give a rapid boost to human knowledge development by allowing exploration of paradigms and anomalies never seen before. Thus, working in teams (face-to-face, intellectual or virtual) becomes inevitable; teamwork has become the science standard rather than the exception. The knowledge is now contained within the team, meaning that the team has become the new "science unit."

The team as the new "science unit" also evolves with the development of knowledge. In the beginning of science branching and sub-speciality development, team interactions were within a science field (e.g. team of doctors in one department). The new knowledge and understanding of human diseases has pushed the boundaries of teams across disciplines with new team members representing different levels of care giving, diverse knowledge fields, varied technology, and dispersed physical locations.

Roles of the team facilitators

The pressure to co-ordinate between intellectual teams requires team facilitators to be knowledgeable in the subject matter, the technology, and the interpersonal dynamics, and to have well-developed communication skills and consensus-building abilities, as well as a systems perspective, which recognises the interdependence between and among team members' specialities. It is possible that over time, due to developing communication and knowledge constraints, the team's "central person" (in terms of communication and co-ordination) would tend to specialise and secondary "central persons" would emerge – leaders that facilitate the contact not between team members, but between the individual teams' facilitators. These communication facilitators would represent the third level of "science units," having overview knowledge of diverse scientific fields and being able to recognise links and interactions not exploited before.

INTERRELATEDNESS OF SCIENCE AND TEAM DEVELOPMENT

The schematic representation of the evolution of the science units and the role of teams and team facilitators are presented in Figure 1. In the future, communication and knowledge would not be contained within one team; rather, they will be co-ordinated between a team of teams, a ***consortium*** of teams, where the team members are other, more narrowly specialised teams, representing a variety of organisations and industries. The facilitator between these multiple teams (A in Figure 1) would be self-similar to the ancient philosopher, just at a higher level of knowledge, coordination and interaction. In order to effectively co-ordinate tasks with ever increasing complexity, that individual would have to be knowledgeable in a number of different teams' scientific areas, be able to imagine the links between different

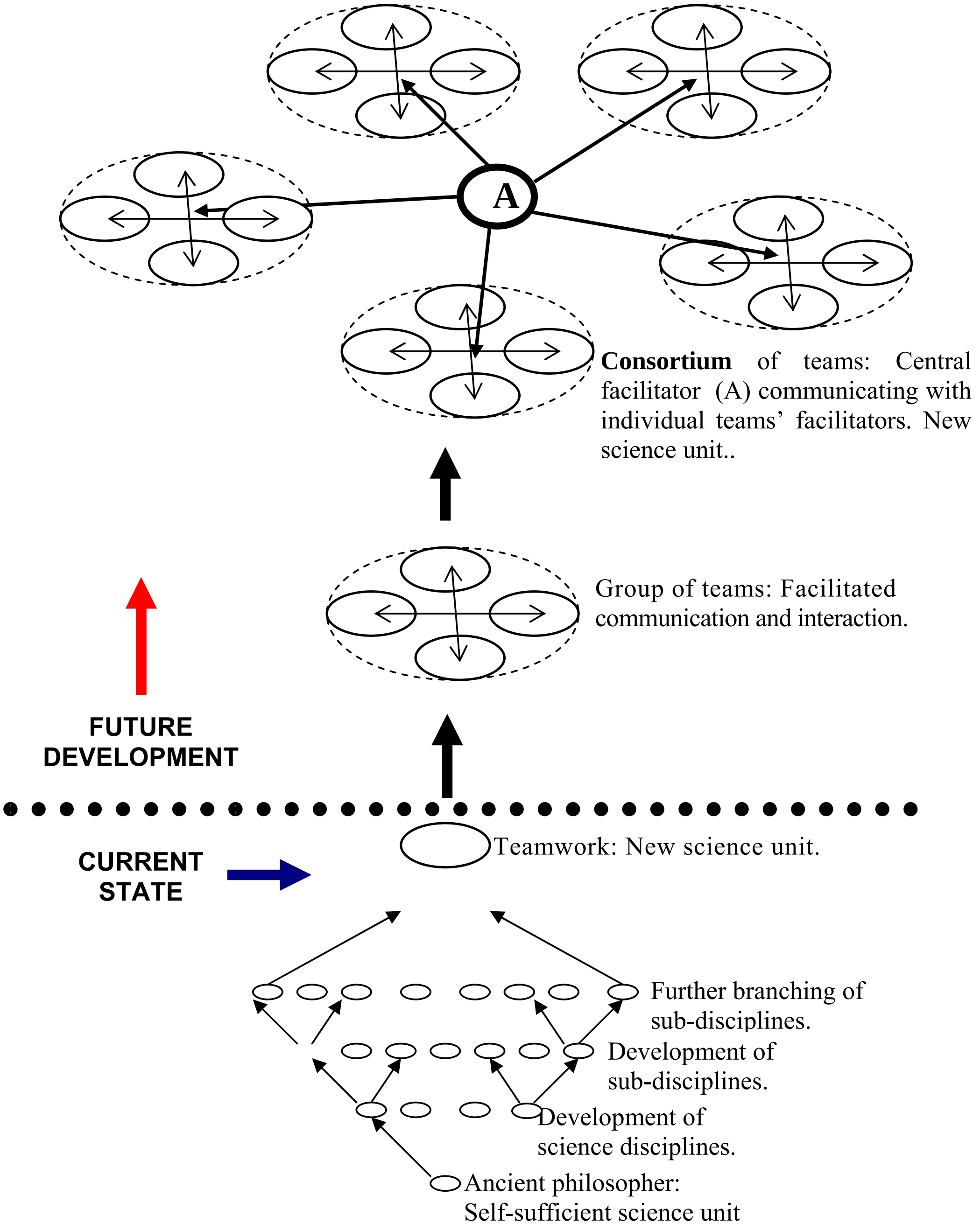


Figure 1. Schematic of the new concept of science and team development.

kinds of knowledge, and recruit, construct and utilise all existing pertinent knowledge into maximally effective work design and outcomes.

APPLICATION OF THE NEW CONCEPT OF SCIENCE AND TEAM DEVELOPMENT

This innovative idea about the interaction in the development of science and teams might have important implications in a variety of aspects:

1. **development of science**: Scientists are no longer working autonomously; teams of scientists from different fields perform interdisciplinary research to augment the positive potential of their studies of the anomalies. Interdisciplinary work and teams including members with various skills are not the rare exclusion, but the scientific standard,
2. **development of education**: Changes in the way students are being prepared to advance in their studies and conduct research would become necessary. Collaborative work and team-skills would be absolutely critical in preparation for the work place. The concept of continuous learning would be the central paradigm for students, professors and researchers,
3. **workforce development**: The need for new work-style and interpersonal skills with attention to interdisciplinary approaches would spread over the entire workforce. Implementation of research into practice would speed these requirements for changes in workforce development,
4. **interdependence of science and teamwork**: Science and teamwork are interrelated and interdependent. The process of mass globalisation of education, business and research would promote teamwork as the standard of scientific development. Therefore, more knowledge about the processes within a team and between and among consortium teams would need to be developed. Without proper development of teams, the boost of new scientific discovery might be delayed,
5. **new research toolbox**: New research toolbox needs to be created in order to study the dynamic changes in knowledge, science and team development, multi-level and multi-team interactions, consortium partners' interrelatedness, and in order to predict the future developments of science and teams.

RESEARCH APPROACHES IN STUDYING SCIENCE AND TEAMS

Although separately studied, the fields of knowledge, science and team development have not been studied from the viewpoint of their interrelatedness and interactions. Therefore, a new "research toolbox" should be developed to allow emphasis on their interrelatedness and dynamics. Overall, the availability of various research approaches in other scientific disciplines is perceived as an advantage in studying the connection between the two concepts of teamwork and science development, and in defining a new method in research in science, based on the interrelatedness with teamwork constructs.

Use of computer modelling would be useful in validating the suggested new idea about the interrelatedness of science and team development, and in studying of the predicted interactions and dynamics in team consortiums. As the next step in research, input of historic data about known scientific developmental milestones, known parameters from the Chaos and other theories, as well as team parameters and mapping models, would allow building of a computer model to further study the possible implications of science and teamwork interrelatedness.

Borrowing approaches from other scientific fields will help to define and adapt research methods to organize and implement a specific array of research methods to best suite the study of the interrelatedness of science and team development. In the light of this, to make the research more animated, the following research agenda is suggested for future studies:

1. mapping of teamwork dynamics in complex teams in relation to various facilitator characteristics,
2. use of computer models with known and suggested data to study science and team interrelatedness,

3. in-depth study of models of facilitator-to-facilitator and facilitator-to-team interactions in complex teams and team consortiums to determine needs for facilitator training and education,
4. continued study of facilitator characteristics with focus on applications to team consortium interaction models,
5. studies of modes of operation in complex teams and teamwork evolution, especially in the context of dynamically evolving environments,
6. study of the changes in interactions between intelligent systems and human facilitators with emphasis on development of new approaches to solving multidimensional problems,
7. continued study of the reliability of intelligent systems' advice, guidance, information and expertise as compared to human intelligence and expertise under different conditions of task complexity and stress levels,
8. comparative studies of human resource workload changes and success in task completion by teams under varied conditions of facilitated communications,
9. study of the development of team culture in complex teams and team consortiums, and its impact on new scientific developments,
10. defining and studying the implications of the science and team development interrelatedness to the notion of "area of specialization" as pertinent to facilitated communications. There is a need to define the skill set and possible training lines for complex team facilitators and facilitators in team consortiums.

This new idea about the interrelatedness of knowledge, science and research needs to be studied and validated by known, adapted or newly created scientific approaches. Even with the utilization of advanced technology, building of interpersonal relationships and informal communication systems is expected to remain pivotal in teamwork and problem solving. Therefore, attention to the emotional component of interpersonal relationships will remain to be of critical importance in team development and future studies of science and teamwork development.

Talent management, as the way to create excellence, is already capturing the focus of business and research [27]. Identifying, selecting and developing institutional talent is related to allocation of resources and expectations for individual's contributions. Successful businesses start implementing human resource management systems to enhance performance-oriented culture, low turnover of employees, high levels of employee satisfaction, timely obtaining of qualified talent replacements, investment in employee development, and performance evaluation [28]. Applications of talent management in regard to facilitated communications is an area yet to be explored.

IMPORTANCE OF THE NEW IDEA

This new idea about the inter-relatedness of the development of science and teamwork is important because it suggests a very likely future direction for scientific improvement. It shows the necessity of studying the teamwork processes and the possible development of team consortiums, consisting of large numbers of specialised teams with narrowly defined knowledge areas.

The facilitators of the teams of the future would be extremely important in science development. It will become much easier to produce highly specialised engineers, surgeons or genome engineers, than to discover, educate, and develop those individuals capable of the delicate and complex work of multi-team (team consortium) facilitation. Such individuals would emerge as the new scientists of the millenium, with extraordinary knowledge in a variety of fields, unusual mix of abilities, highly developed teamwork and interpersonal skills, and visionary ideas in illuminating bold strategies for new scientific discoveries.

The new scientists of the millennium, through team consortium facilitation, will be able to build bridges between and among the multitude of disperse and extremely specialised knowledge for the further benefit of mankind. Simultaneously, this approach to cross-disciplinary teams provides the opportunity to explore issues at a deeper level by highly-specialised scientists and to understand the relationships between and among key specialisations in addressing issues systemically; thus, increasing the probability that root causes would be addressed, rather than symptoms, which is more likely from an individual, isolated discipline approach. The increasing complexity of exponential knowledge growth and work interdependency calls for changes in the scientific way of thinking and functioning, and for even deeper changes in our educational systems and workforce development strategies.

ACKNOWLEDGMENTS

The authors would like to gratefully acknowledge the valuable contributions to the discussion of the chaos theory and its applications made by Mr. Steve Randolph, senior analyst and computer modelling expert with the Michigan-based Altarum Institute. The authors would also like to thank Ms. Yan Zhang, graduate student in Educational Administration at Texas A&M University, for her technical support during the revision of this paper.

REFERENCES

[1] Kuhn, T.S.: *The structure of scientific revolutions*. 3rd edition.
Chicago: The University of Chicago Press, 1996,

[2] Rae, G.: *Chaos theory: A brief introduction*.
http://www.imho.com/grae/chaos/chaos.html,

[3] Lucas, C.J.: *American higher education: A history*.
New York: St. Martin’s Griffin, 1994,

[4] –: *American Board of Medical Specialties*.
http://www.abms.org,

[5] Clark, P.G. and Drinka, T.J.K.: *Health care teamwork: Interdisciplinary practice and teaching*.
West Port: Auburn House, 2000,

[6] Katzenbach, J.R. and Smith, D.K.: *The wisdom of teams: Creating the high-performance organization*.
Boston: Harvard Business School Press, 1993,

[7] Hare, A.P.: *Groups, teams and social interaction: Theories and applications*.
New York: Praeger Publishers, 1992,

[8] Kidder, T.: *The soul of a new machine*.
Boston: Little Brown, 1981,

[9] Hackman, J.R.: *The design of work teams*.
Lorsch, J.W., ed.: *Handbook of organizational behaviour*. Prentice-Hall, Englewood Cliffs, pp. 315-342, 1983,

[10] Brooks, F.B.: *The mythical man-month*.
Reading: Essays on software engineering. Addison-Wesley, 1982.

[11] Hollingshead, A.B.: *Communication, learning, and retrieval in transactive memory systems*.
Journal of Experimental Social Psychology **34**(5), 423-442, 1998,

[12] Hollingshead, A.B. and Brandon, D.P.: *Potential benefits of communication in transactive memory systems*.
Human Communication Research **29**(4), 607-615,

[13] Hayne, S.C.; Smith, C.A.P. and Vijayasarathy, L.R.: *The use of pattern-communication tools and team pattern recognition*.
IEEE Transactions on Professional Communication **48**(4), 377-390, 2005,

[14] Akgün, A.E.; Byrne, J.C.; Keskin, H. and Lynn, G.S.: *Transactive memory system in new product development teams*.
IEEE Transactions on Engineering Management **53**(1), 95-111, 2006,

[15] Nevo, D. and Wand, Y.: *Organizational memory information systems: a transactive memory approach*.
Decision Support Systems **39**(1), 549-562, 2005,

[16] Perry, A.; Bryson, S. and Bebko, J.: *Brief Report: Degree of Facilitator Influence in Facilitated Communication as a Function of Facilitator Characteristics, Attitudes and Beliefs*.
Journal of Autism and Developmental Disorders **28**(1), 87-90, 1998,

[17] Perry, L.: *Effective facilitators – a key element in successful continuous improvement processes*.
Training for Quality **3**(4), 9-14, 1995,

[18] McFadzean, E.: *Developing and supporting creative problem solving teams: part 2 – facilitator competencies*.
Management Decision **40**(6), 537-551, 2002,

[19] Dillon, K.M.; Fenlason, J.E. and Vogel, D.J.: *Belief in and use of a questionable technique, facilitated communication, for children with autism*.
Psychological Reports **75**, 459-464, 1994,

[20] Niederman, F. and Volkema, R.J.: *The Effects of Facilitator Characteristics on Meeting Preparation, Set Up, and Implementation*.
Small Group Research **30**(3), 330-360, 1999,

[21] Pauleen, D.J. and Yoong, P.: *Relationship building and the use of ICT in boundary-crossing virtual teams: a facilitator's perspective*.
Journal of Information Technology **16**(4), 205-220, 2001,

[22] Edigo, C.; Galegher, J. and Kraut, R.E.: *Intellectual teamwork: Social and technological foundations of cooperative work*.
Hillsdale: Lawrence Erlbaum Associates, 1990,

[23] Oakley, J.G.: *Leadership processes in virtual teams and organizations*.
Journal of Leadership Studies **5**(3), 3, 1998,

[24] Grabowski, M. and Sanborn, S.D.: *Human performance and embedded intelligent technology in safety-critical systems*.
International Journal of Human-Computer Studies **58**(6), 637-670, 2003,

[25] Mandel, M.: *The real reasons you are working so hard*.
Business Week **3953**, October 3, 2005,
http://yahoo.businessweek.com/magazine/content/05_40/b3953601.htm,

[26] Quesenbery, W.: *Who is in control? The logic underlying the intelligent technologies used in performance support*.
Technical Communication **49**(4), 449-457, 2002,

[27] Oakes, K.: *The emergence of talent management*.
Training and Development **60**(4), 21-23, 2006,

[28] Berger, L.A. and Berger, D.R.: *The talent management handbook: creating organizational excellence by identifying, developing and promoting your best people*.
McGraw Hill, 2004.

ZNANOST I RAZVOJ GRUPA

R.B Akins i B.R. Cole

[1]Odjel pedijatrije, Centar za zdravstvene znanosti Sveučilišta *Teksas Teh*
El Paso, Sjedinjene Američke Države
[2]Odjel za administraciju obrazovanja i razvoj ljudskih resursa, Sveučilište A&M u Teksasu
College Station, Sjedinjene Američke Države

SAŽETAK

U radu se istražuje nova zamisao o budućem razvoju znanosti i grupa te predviđaju posljedice takvog razvoja u znanosti, obrazovanju i razvoju i istraživanju radne snage. Međusobna povezanost razvoja znanosti i grupnog rada upućuje na rastući značaj kvalitete vođe grupe, kao i na značenje detaljnih studija procesa u grupama i konzorcijima grupa na rastuću kompleksnost eksponencijalnog rasta znanja i međuovisnosti poslova.

U budućnosti će biti jednostavnije osposobiti specijalizirano osoblje, npr. neurokirurge i inženjere genoma, nego izdvojiti, obrazovati i razviti pojedince sposobne za osjetljiv i kompleksan posao vođenja konzorcija grupa. Takvi pojedinci će postati novi znanstvenici tisućljeća, izuzetnog znanja u nizu znanstvenih polja, neuobičajene kombinacije sposobnosti, visoko razvijenih vještina grupnog rada i vizionarskih pristupa širenja odvažnih strategija za nova znanstvena dostignuća. Novi znanstvenici tisućljeća, putem vođenja konzorcija grupa, bit će sposobni izgraditi mostove između mnoštva različtih i izuzetno usmjerenih znanja i povezanih funkcija, radi poboljšavanja sustava i daljnjeg doprinosa čovječanstvu.

KLJUČNE RIJEČI

razvoj timskog rada, razvoj znanosti, razvoj koncepta, međusobna povezanost znanosti i timskog rada