Chapter 1
David Pines and Me

Kazuo Nishimura

Abstract When a large number of elements are interrelated and the entire system exhibits complex behavior, the behavior of the individual elements often does not explain the behavior of the whole. This phenomenon is common not only in life, the global environment, and throughout the universe, but also in many other fields, including economy and society and is called the complexity. The author has been studying the complexity in economics since receiving his Ph.D. from the University of Rochester. This chapter looks back over events linking the Santa Fe Institute, the Institute for Complex Adaptive Matter, and Kyoto University, in addition to establishment and activities of the International Research Unit of Integrated Complex System Science (IRU-ICSS), beginning with his encounter with David Pines. Pines was one of the founders of the Santa Fe Institute, the Mecca of complex systems research. In addition, the author reflects on the activities he has been involved in to improve science and mathematics education with Pines and the complex systems researchers at Kyoto University who are members of IRU-ICSS. The education system is also an example of a complex system.

1.1 Meeting David Pines

There are two American researchers who have acted as my mentors in economics. They are Lionel McKenzie (University of Rochester) and David Pines (Santa Fe Institute). McKenzie was my doctoral advisor when I obtained a Ph.D. in mathematical economics. Pines was a physicist who acknowledged my research and brought me into the world of complex system researchers.

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The International Research Unit for Integrated Complex System Science (IRU-ICSS) at Kyoto University has been advised by Pines since its inception. In this chapter, I review the activities of the unit from its inception to the present with a focus on the interaction with David Pines.

The Santa Fe Institute emerged from a concept by George Cowan, a physical chemist at the Los Alamos National Laboratory, and was founded with the endorsement of physicists David Pines, Murray Gell-Mann, and Philip Anderson, and economist Kenneth Arrow. It was founded as a research institute in 1984 in Santa Fe, in the state of New Mexico, USA. Both Gell-Mann and Anderson received a Nobel Prize in Physics; Arrow received a Nobel Prize in Economics.

Complex systems are composed of many components that may or may not be mutually interdependent. These systems are a complex interplay of components, in which a part may influence the whole and the whole may affect a part. Such phenomena can be seen in many areas, ranging from nature to human society, in life, the global environment, economics, and other fields. They offer perspectives that differ from and may be unattainable through conventional reductionism. Complex systems have grown into a new field of research, through development of chaos theory and fractal theory and the application of computing power. The book *Complexity* by Waldrop (1992) introduced research being undertaken at the Santa Fe Institute. This publication became a bestseller, and the Santa Fe Institute suddenly rose to a position of renown as a Mecca for the study of complex systems.

The Santa Fe Institute also hosts economists who engage in joint research with physicists. In the early days of the institute, economists included José Scheinkman (Princeton University), who was senior to me at the University of Rochester, and Michele Boldrin (Washington University in St. Louis), junior to me at the same university. We all shared the same advisor, Lionel McKenzie. I too served as an external professor at the Santa Fe Institute, over 9 years from 2008.

In late 1992, I was invited to a complex systems symposium in Tokyo, held in December on the Hongo Campus of the University of Tokyo. Participants from overseas included members of the Santa Fe Institute. Domestic participants included Akito Arima (physicist and President of the University of Tokyo at the time), Minoru Oda (astrophysicist and President of RIKEN at the time), University of Tokyo researchers Kunihiko Kaneko (statistical physics), Hiroshi Shimizu (pharmaceutical sciences), Youichi Kaya (systems engineering), and others. At the time, there were no researchers of complex systems at the Faculty of Economics, University of Tokyo. For that and other reasons, I was invited from Kyoto University to speak.

I talked about research on nonlinear dynamics in the field of economics. Specifically, this included results of joint research undertaken with Jess Benhabib (New York University) (Benhabib & Nishimura, 1979a, 1979b, 1985) and W. Davis Dechert (State University of New York at the time) (Dechert & Nishimura, 1983). My presentation also turned to results of ongoing research then being undertaken by Makoto Yano (Yokohama National University at the time) concerning the oscillations and chaotic behavior of solutions of infinite-dimensional optimization problems.

Brian Arthur, of the Santa Fe Institute, was a discussant of my lecture. Arthur featured prominently in the book *Complexity*, which was released in the USA in

November 1992. He explained the oscillations in the growth path of the economy by comparing it to the path of an airplane and its fluctuations. During the break following my presentation, Arima and Pines asked questions and offered comments. Arima and Pines had been close friends from days long past, and both held my research in high regard.

Minoru Oda, who attended the symposium at the University of Tokyo, was later appointed to the post of President of Tokyo University of Information Sciences. In April 1998, he organized an international conference titled "Human Beings—Inside and Out." I was asked to give a guest lecture at the conference, and was delighted to catch up with Pines, who had of course also been invited. Whereas I spoke on complex systems in economics, Pines gave a presentation titled *Designing a University for the Millennium: A Santa Fe InstitutePerspective.* Oda spoke on *How We have Become Complex Human Beings*, while Hida Takeyuki of Meijo University gave a lecture titled *Fluctuation, Nonlinearity and for Human Beings.* The conference ran over two days, and Pines and I therefore had time to talk at length about each other's research. We discovered common ground and found we were kindred spirits in our thinking on research. Minoru Oda was also a friend of Pines. Later, through activities in complex systems and sciences education, Kyoto University astrophysicists who worked with us would all come under Oda's direct or indirect guidance. Pines would become a cornerstone in the process of forming a complex systems network at Kyoto University.

Born in 1924 in Kansas City, Missouri, Pines graduated from the University of California, Berkeley, in 1944, and then began physics research in the Berkeley graduate division. In 1947, Pines transferred to Princeton University Graduate School where, under the supervision of David Bohm, he continued research. Bohm was a former student of Robert Oppenheimer, who had a leading role in the Manhattan Project at Los Alamos. In 1952, Pines transferred to the University of Illinois at Urbana-Champaign, where he engaged in post-doctoral research under the guidance of John Bardeen. Pines then left the University of Illinois in 1955 to take an appointment as an assistant professor at Princeton University. After the departure of Pines, Leon Cooper took the position of post-doctoral researcher under John Bardeen. Cooper, Bardeen, and Bob Schrieffer (a postgraduate student of Bardeen) further developed the research Pines had engaged in under Bardeen. In 1957, Cooper, Bardeen, and Schrieffer presented a theory that elucidated the phenomenon of superconductivity. For that work, Cooper, Bardeen, and Schrieffer jointly won the Nobel Prize in physics in 1972.

1.2 Complex System Research at Kyoto University

In 1987, I took on a position as professor at the Institute of Economic Research, Kyoto University. Kyoto University had a strong base of complex system research. Yoshisuke Ueda at the time was at the School of Electrical and Electronic Engineering. In 1961, as a doctoral student, Ueda discovered the Strange Attractor while

conducting computer simulations of nonlinear ordinary differential equations applied to electrical circuits. This attractor is called the "Ueda Attractor" or "Japanese Attractor." An international conference organized by Ueda was attended by Ralph Abraham, Mitchell J. Feigenbaum, James Yorke, and numerous other prominent people in complex system research outside Japan. In particular, the mathematician Ralph Abraham, a co-author of *Transversal Mappings and Flows* (Abraham & Robbin, 1967) frequently visited Kyoto University to take part in joint research with Ueda. I had read that book while in graduate school in the USA. On one such visit, he gave a seminar at the Institute of Economic Research. Abraham saw my thesis in my office and said that, had he been an economist, he would certainly have wanted to delve into that. Through my relationship with Ueda, I also became acquainted with Tohru Kohda (Faculty of Engineering, Kyushu University) and Yoichiro Takahashi (Research Institute for Mathematical Sciences, Kyoto University). Subsequently, I was invited to join the editorial board for the first issue of *Chaos, Solitons and Fractals* (Elsevier). Ueda taught me much about the way of thinking as a researcher.

In the 1990s, I was invited to serve on the editorial boards of various other international academic journals, in areas including economics, mathematics, and interdisciplinary fields. Those are ongoing.

In 1993, Tadashi Shigoka joined the Institute of Economic Research, shortly after obtaining a Ph.D. from Yale University with his thesis on nonlinear economic dynamics. In 1995, Masahisa Fujita, who had served for many years as a professor at the University of Pennsylvania, took a position at the Institute of Economic Research. Fujita undertook an analysis of "Cities, regions and international trade as complex systems of spatial economies." In the following year, Tomoya Mori, who had obtained a Ph.D. at the University of Pennsylvania under the supervision of Fujita, was brought into the group.

In 1996, I served as a leader in an application for status as a Center of Excellence (COE). The Center of Excellence initiative was sponsored by the Ministry of Education to support mainly international research activities of research groups that had already produced internationally acknowledged yields. Our bid was accepted and in 1997 we launched a project to form a COE for complex economic systems. This would become the second COE at Kyoto University, following the group set up in 1995 by Tasuku Honjyo and Shigetada Nakanishi of the Faculty of Medicine. Our project was completed in 2003, and in 2004 the Center for the Research of Complex Economic Systems was opened within the Institute of Economic Research.

Meanwhile, in 2001, the Institute of Economic Research sponsored an interdisciplinary international conference on complex system science. Not limited to economists, participants in the conference included David Pines and Kunihiko Kaneko in physics, Yoshisuke Ueda and Kazuyuki Aihara (University of Tokyo) in engineering, Christof Koch (Caltech) and Gen Matsumoto (RIKEN) in brain science, and Kazuhiko Aomoto (Nagoya University) and Saber Elaydi (Trinity University) in mathematics.

Ueda spoke on the Strange Attractor he had discovered in 1961, in a presentation titled *Origin of the Broken-Egg Chaotic Attractor*. Christof Koch is renowned as a leading researcher in the field of consciousness. At the time, he was engaged

in joint research with Francis Crick, who was famed for discovery of the double-helix structure of the DNA molecule. In 1995, I began looking at measurement of brain activity in trying to explain human behavior. From around 2000, brain science research by economists became established as a field known as neuroeconomics. Saber Elaydi is Editor-in-Chief of the *Journal of Difference Equations and Applications* (JDEA), for which I have been on the editorial board. Through Elaydi, I became acquainted with distinguished mathematicians including James Yorke, who is famed for the paper *Period Three Implies Chaos*, and Alexander Sharkovsky, known for the "Sharkovsky Ordering." James Yorke also took part in the 2007 International Conference on Difference Equations and Applications (ICDEA), which was jointly sponsored by the Mathematical Society of Japan and the Institute of Economic Research, Kyoto University.

When David Pines visited Japan for the 2001 International Conference on Complex System Science, he talked about a concept for a new complex system research institute. At the time, I was not clear on the details of what form it might take. Several years later, while at home in Tokyo in December 2004, I received an unexpected telephone call from the Graduate School of Science at Kyoto University. They told me that David Pines was visiting Kyoto University, and asked whether I could return quickly to Kyoto. The phone call was from Satoru Nakatsuji, a lecturer at the Department of Physics. Nakatsuji (now a professor at the University of Tokyo) and Pines had published a joint paper on the Kondo Lattice in the American Physical Society journal, *Physical Review Letters.*

Returning to Kyoto without delay, I met Pines and engaged in discussion together with several scientist friends of mine. I remember one of those friends was greatly moved on meeting Pines, having read and studied writings by Pines during his days in university. At the time, Pines was accompanied on his visit to Japan by his wife, Suzy. Pines was, needless to say, good friends with Arima and Oda, and well acquainted with many Japanese physicists who could have been regarded as his disciples. Suzy, too, had many friends here, and a visit to Japan was enjoyed as a reunion of old friends.

The network-style Institute for Complex Adaptive Matter (ICAM) had been founded two years earlier in the USA, and Pines had come to Kyoto University with the objective of opening a branch in Japan. Professor Makoto Yao of the Department of Physics and I discussed the matter, and the decision was made to open a Kyoto branch of ICAM, centered on the Institute of Economic Research and the Department of Physics. The branch was named ICAM/Kyoto. Incidentally, another ICAM branch was established in Japan, in the Institute for Solid State Physics at the University of Tokyo.

At the Institute of Economic Research, Kyoto University, projects led by the Center for the Study of Complex Economic Systems were selected for the 21st Century COE Program (2003–2007) and the Global COE Program (2008–2012) of the Ministry of Education. ICAM/Kyoto thus served as another point of contact between complex system researchers at Kyoto University and the world.

To commemorate the establishment of ICAM/Kyoto, the public lecture *Invitation to Chaosand Complex Systems* was held at Kyoto University in October 2005.

Akito Arima, David Pines, Makoto Yao, and I were speakers. After serving as the President of the University of Tokyo, Arima became the Minister of Education from 1998 to 1999, and was in a position to promote a relaxed education policy that is a commonly called *Yutori Kyouiku.* In the midst of this, I published a book entitled *University Students Who Cannot Do Fractions* (Okabe et al., 1999) and criticized relaxed education, which put us in a position of direct conflict. Considering this, it was doubtful whether Arima would have been willing to participate. The people involved, including Yao, were well aware of this. However, it was natural for Arima, a physicist and friend of Pines, to give a lecture at the inaugural public lecture of ICAM/Kyoto. Arima took a mature approach and accepted to give the lecture.

When ICAM was founded, David Pines and Daniel Cox served as co-directors. Cox, a professor with the Department of Physics at the University of California, Davis, visited the Institute for Solid State Physics at the University of Tokyo and the Department of Physics at Kyoto University in 2006.

ICAM was not only conducting research, but also projects to improve the standard of science education, which was in line with my own efforts to improve mathematics education in Japan. In June 2007, I organized an international conference, named the "Interdisciplinary Conference on the Sciences of Complexity and Science Education," and invited James Yorke and Yoichiro Takahashi of chaos, Toshiaki Imada (University of Washington) of brain science, and others, and Pines also gave a presentation. His lecture was chaired by Satoru Nakatsuji, who had transferred from Kyoto University to the University of Tokyo. I had met Yorke on numerous occasions at conferences organized by Elaydi and by that time we were good friends. He had many Japanese friends and disciples; he was a Japanophile, and I too sought out the opportunity to take him to dinner whenever he came to Japan. Although we did not have the opportunity to write a joint paper, conversations with Yorke were often helpful in my research. The same could be said for Pines, and I often got many hints for my research from conversations with him.

Due in part to these efforts, ICAM/Kyoto has steadily promoted interaction with the complex systems group at Kyoto University. Makoto Yao of the Department of Physics, Masatoshi Murase of the Yukawa Institute for Theoretical Physics, Kazuyoshi Yoshimura of the Department of Chemistry, and others have taken part in ICAM international conferences held at the University of California and the Santa Fe Institute.

Meanwhile, I was appointed to the post of External Professor at the Santa Fe Institute (Fig. 1.1) in 2008, and began visiting the institute every year.

In April 2010, I reached retirement age at Kyoto University. Video messages from Pines, Yorke, Elaydi, and from Lionel McKenzie, who had been my advisor for my Ph.D. thesis at the University of Rochester, were replayed during the retirement party. Even after retirement, I have continued my research as a specially appointed professor at the Institute of Economic Research.

Against this background, in 2010, the International Research Unit for Integrated Complex Systems Science (IRU-ICSS) was established at Kyoto University as a cross-disciplinary, interdisciplinary research organization, with members of ICAM/Kyoto playing a central role, and I served as the first Director of the unit.

Fig. 1.1 With David Pines—at the entrance to the Santa Fe Institute

That post was taken up by Kazuo Mino (Institute of Economic Research) in 2013, and then by Kazuyoshi Yoshimura (Graduate School of Science) from 2015.

In December 2010, Jeremy A. Sabloff, President of the Santa Fe Institute, visited the Kyoto University IRU-ICSS. Sabloff returned to Japan in October 2012 and presented a lecture during the Santa Fe/Kyoto Symposium, "An Invitation to Complex System Science," held at Kyoto University Science Seminar House. On the following day, he gave a seminar at Kyoto University Museum, where Terufumi Ohno was at the time serving as museum director.

In June 2013, Luis Bettencourt of the Santa Fe Institute visited the Institute of Economic Research. During an Urban Economics Workshop held by the Institute of Economic Research, Bettencourt gave a report on research he was conducting in relation to a city project being undertaken by the Santa Fe Institute.

Meanwhile, Pines and I would discuss various issues whenever he came to Japan or I visited Santa Fe. Pines was more than 80 years old, but he was constantly actively engaging in new projects. Although his comments during Santa Fe Institute seminars and other occasions were frank and to the point, and he had a severe side when it came to academic matters, Pines was ever warm and welcoming toward his colleagues and juniors. Pines always applied positive thinking in regard to life, and talking with him never failed to stir courage and a positive attitude. When discussing a particular project with him, he said, "There is never any need for stress or anxiety in our work. We are in this because we enjoy doing it." We were in two different fields of work, but the 20 years of interaction since we met at conferences in Tokyo and the Tokyo University of Information Sciences were all due to his broadminded thinking and character.

1.3 Measures to Raise the Level of Science and Mathematics Education

A number of complex system researchers were also members of the Kyoto Prefectural Board of Education/Kyoto University Collaborative Project Committee, which was set up in 2010 to help improve science and mathematics education in public schools in Kyoto Prefecture. This committee was established, centered on Terufumi Ohno, Director of the Kyoto University Museum at the time.

ICAM/Kyoto and the IRU-ICSS united in 2010 to undertake complex system research. Since then, in the area of science education, the Kyoto Prefectural Board of Education/Kyoto University Collaborative Project Committee has worked on raising the science and mathematics abilities of students in public schools. Activities included visiting classes, symposiums, and events at museums and observatories.

From the start, the Santa Fe Institute too has endeavored to promote science and mathematics education, in parallel with complex system research. The Santa Fe Institute provides visiting lectures for junior and senior high schools, and conducts summer schools. Among other activities, there is a High School Prize for Scientific Excellence, awarded to a senior high school that provides outstanding science education. Since 2008, when I became an external professor at the Santa Fe Institute, David Pines, of the Santa Fe Institute and ICAM, and I, at Kyoto University, became mutual points of contact between the institutions, and promoted programs aimed at elevating science education.

In March 2015, Irene Lee, Director of the Learning Lab at the Santa Fe Institute, visited Kyoto University. During the IRU-ICSS Workshop, held in the third-floor lecture room of Kyoto University Museum, she gave a presentation on the topic *Computer Modeling and Simulation in American Education.* She also gave a visiting lecture at a Kyoto Prefectural senior high school. That lecture was arranged by the Kyoto Prefectural Board of Education.

In the area of science and mathematics education, Pines used the ICAM international network to set up the Global Partnership on Science Education through Engagement (GSEE), bringing together activities in science and mathematics education throughout the USA and Europe. I was involved in the endeavor in Japan, where GSEE/Kyoto was established with distinguished advisors. At GSEE/Kyoto, it was Pines' suggestion to ask for help from Akito Arima. I had some hesitation in doing so, since Arima was the one who promoted the idea of a relaxed education policy and I was the one who tried to stop it. However, I thought that Arima would agree with the project to improve the standard of science education, so I decided to ask him. Arima gladly agreed to become an advisor to GSEE/Kyoto. As a result, GSEE/Kyoto started with members including Akito Arima, Michiharu Nakamura (former President of JST), Professor Makoto Kobayashi (winner of a Nobel Prize in Physics), Hiroo Imura (former President of Kyoto University), Kazuo Oike (former President of Kyoto University), and Kazuo Kitahara (Professor at Tokyo University of Science) in the advisory board of GSEE/Kyoto. Such members would not have been obtained without the close relationship shared by Pines and Arima.

I used to visit the office of the President of Musashi Gakuen, which was located in the campus of Musashi University in Ekoda, Tokyo, where Arima was the president at that time, and have frequent meetings with him. Arima seemed to enjoy it, and I was later told by the vice-minister of the Ministry of Education that Arima had happily told him that he was working with me on science education activities.

In May of 2012 and 2013, I attended GSEE meetings held at the University of Chicago. The meetings focused mainly on reporting specific applications to science education in areas of the USA.

In April 2013, a preparatory conference, "Science Education in Kyoto 2013," took place at the Yukawa Institute for Theoretical Physics, Kyoto University. That conference was only for Japanese speakers. Members of the Kyoto University IRU-ICSS, ICAM/Kyoto, the Kyoto Prefectural Board of Education/Kyoto University Collaborative Project Committee, and GSEE/Kyoto advisory board attended. A number of senior high school teachers who have been practicing outstanding science education throughout Japan were also selected to give presentations. Then, in October of that year, researchers involved in science education in the USA, Europe, and Asia took part in the main conference, GSEE/Kyoto Summit 2013, which was also held in Kyoto. During the main conference, we heard reports from some of the senior high school teachers in Japan who had given presentations in the preparatory conference. Just before the main conference, a public lecture, *Let's Enjoy Science*, was held on the Kyoto University campus. With talks by David Pines and Makoto Kobayashi, this event was aimed at senior high school students, and attended by many from Kyoto and other prefectures.

Suzy also accompanied David on that occasion. Both were nearing their 90s, but walked straight and tall, and moved about easily and unaided. During the conference, Suzy caught up with old friends as planned. She had specialized in clinical psychology, and was always interested in discussion relating to my research into brain science and education.

After the Kyoto conference, David and Suzy travelled to Tokyo as planned, where they were able to join my family and me for dinner at a restaurant. I had dined with them many times, but this was the first time my family was included.

In June 2015, the GSEE/Taiwan Summit was held at the National Donghwa University, in Hualien, Taiwan. This was organized by Maw-Kuen Wu, President of the university and a physicist specializing in superconductivity. Maw-Kuen Wu later became the Taiwan Minister of Education. The year from 2015 was a difficult time for Pines, as Suzy succumbed to cancer and passed away in October. He was unable to attend the GSEE/Taiwan Summit.

In January of the following year, 2016, the GSEE/Kyoto Summit was held once more at Kyoto University. It was attended by Jyuichi Yamagiwa (President of Kyoto University) and Akito Arima. People involved in science and mathematics education were invited from Japan, China, Taiwan, Hong Kong, and South Korea.

David Pines attended the GSEE/China Summit, held in Shenzhen, China, in December 2016. The "STEM and Gifted Education Conference and Summit" took

place in Hong Kong directly after. The GSEE/China Summit in Shenzhen was sponsored by the physicist Hong Ding (Institute of Physics), whereas Tai-Kai Ng (Hong Kong University of Science and Technology) organized the Hong Kong conference.

1.4 Education in Osaka City

Raising the standard of science and mathematics education in Japan was my motivation in working with Pines on GSEE activities. In many countries, the importance of science and mathematics education has been acknowledged and budgets are being allocated accordingly. In contrast, the current state of science and mathematics education in Japan was troubling. The more conferences I attended, the more apparent it became to me that improving science and mathematics education in senior high school is too late. The work needed to begin with improving teaching of science and arithmetic at the elementary school level.

Since around 2005, I have created self-study textbooks for elementary schools and attempted to raise results of public schools in Tokyo with performance below the Tokyo average to the top level, and to lift results of public elementary schools at the lowest levels in Kyoto Prefecture up to the national average. I was also involved in efforts to raise the grades of children with learning difficulties to the average of their class in a public school in Osaka City.

These attempts produced startling results. However, they were limited to individual schools and individual school years. When a new school principal was appointed, the undertaking was in many cases terminated. Principals are recognized by the Board of Education for their new initiatives. Therefore, when an incoming principal continues a successful project that was started by the previous principal, credit for success continues to go to the previous principal. It does not improve the evaluation of the incoming principal. From that experience, I strongly felt the need to enlist the cooperation of Boards of Education to broaden application of endeavors to improve academic ability. In that regard, collaborative projects being undertaken by the Kyoto Prefectural Board of Education and Kyoto University were invaluable. Additionally, over four years from April 2013, I served as a member of the Osaka City Board of Education. Board member Fujio Ohmori, now a professor at Tohoku University, was appointed as Chairman of the Board in the following year. The Osaka City Board of Education discuss all issues such as the hiring of teachers, the hiring of principals, teacher scandals, and problematic behavior of students, so it was a valuable experience for me to learn about the various issues surrounding schools.

At GSEE international conferences, I spoke about undertakings with Education Boards during presentations. I also reported on the results of a study I had conducted jointly with Tadashi Yagi (Professor at Doshisha University) concerning changes in the productivity of engineers and researchers in Japan. Many of the reports presented by overseas participants concerned guidance in science for senior high students. Almost no other research dealt with arithmetic and science in elementary schools.

Pines and other overseas participants listened intently to my report. That may have been the first time they had encountered such a perspective.

After finishing my four-year term as a member of the Osaka City Board of Education, from 2017 I began working on improving the academic ability and normative awareness of students at public junior high and elementary schools in Osaka City, as an advisor to the Board of Education. This is because I believe that safety and academic achievement are the roles that parents expect of schools. As for normative awareness, it did not take long to see results because the entire city was involved from the beginning. I will give an overview of the results. As for academic improvement, good results have been obtained in the model schools, but it will take time to spread the results to all schools in the city.

First of all, when serving as a member of the Board of Education, I made an effort to emphasize basic morals for preschool education and early elementary school students. In particular, the following four norms were included in the Osaka City Basic Plan for the Promotion of Education: "Be kind to others," "Don't lie," "Follow the rules," and "Study." In an earlier survey I conducted with Professor Yagi and others, we found that these four norms were often taught in early childhood to people who later had achieved social success.

In Osaka City, there were many instances of violent behavior among schoolchildren. Osaka City scored low in nationwide academic achievement tests, and the city has had the worst ranking in a nationwide study of school violence. Until 2014, the rate of student violence per 1000 students was more than three times the national average. So, first, we "pre-declared" the rules in writing, which are things that are natural not to do.

Virtually no schools in Japan have a clear set of rules that specify what children should not do. There are school precepts and school regulations, but those kinds of rules are different. School precepts tend to be abstract. School regulations are not necessarily about specific actions, but about attitude and dress. In extreme cases, school regulations may place restrictions on students such as specifying that underwear should be white, or that hair should be dyed black if it is not already so. In fact, a case had been brought to court about an Osaka Prefecture senior high school that compelled a student with naturally brown hair to dye it black. On the matter of bullying, in many instances discussion focuses on why it happened; that is, after the event. However, students can be clearly shown beforehand, obvious "things they should not do," such as hiding something belonging to someone else, ignoring, or hitting, etc. If the school then takes immediate action upon occurrence of such events, in many cases matters should not develop to the point of bullying.

Of course, some people might say these things obviously should not be done even if they are not codified in writing. However, in law there is the principle of nonretroactivity, which means you should not be punished for an action taken before a law was enacted to make that action illegal. The same thing applies in schools. A child who is judged for an action despite the absence of a rule forbidding it will likely feel indignation.

On 17 November 2015, the Osaka City Board of Education announced a set of "Rules for School Safety" that specified what children obviously should not do, and a

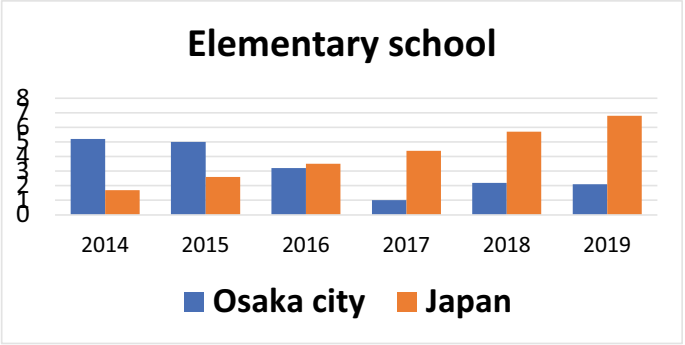

Fig. 1.2 Trends of school violence rates (per 1000 children) in Japanese elementary schools

set of responses to be taken if a child broke a rule. The significance of the responses is that they reinforce children's awareness of what they should not do, thereby reducing problem behavior.

Promoting understanding of the Rules for School Safety among parents and children, raising awareness of the rules with posters and rules tables did reduce cases of violent behavior as the rules were accepted (Fig. 1.2). By the 2017 school year, the number of cases had fallen to 25% of that in 2014. In particular, violent incidents in Osaka City elementary schools fell to 1 child per 1000, in contrast to the national average of 4 children per 1000. Surveys of the children also showed an increase in the number who said they enjoyed school.

The efficacy of the Rules for School Safety stems from the fact that even infraction of rules for small problems have been dealt with in a consistent manner. This has also prevented small issues from developing into major problem behavior. It is understandable that emphasis tends to lean toward dealing with serious problem behavior. However, the functions of the Rules for School Safety are in prior clarification and the willingness to apply them to even seemingly trifling matters, thereby raising children's awareness.

Concerning the improvement of academic ability, we set out to apply what had been learned from implementation in single school years and individual schools in Tokyo, Kyoto, and Osaka, to all schools in Osaka City. We prepared teaching manuals on arithmetic and Japanese language for teaching staff. Implementation of classroom instruction based on the manuals then began at about 80 model schools. Application of the manuals spread from the model schools to all elementary schools in the city from April 2019. As good results were obtained in the subjects' arithmetic and Japanese language, the undertaking was expanded to include sciences from the middle of 2018. This endeavor may be regarded as a GSEE version for elementary schoolchildren. David Pines would no doubt have been very pleased, had I been able to report the results.

1.5 Farewell to David

In the latter half of 2017, I received a message from Pines, saying that he had been diagnosed with cancer and would begin treatment. He would also be suspending his GSEE activities. Pines had lost his wife, Suzy, to cancer two years earlier, so this was deeply disturbing. Then, on 5 May 2018, I received a message titled "David." His family informed me that David Pines had passed away. It was just before his 94th birthday. He had moved from New Mexico to Illinois, where his children lived, and had been undergoing treatment there.

Despite his considerable achievements, Pines missed receiving a Nobel Prize as he had been away from the University of Illinois for four years from 1955. The main media reported his death as a loss to society, and gave high acclaim to the yields of his research and his contribution to society (Chang, 2018).

While working to the last with ICAM and the Santa Fe Institute, Pines continued his research throughout America, of course, and around the world, teaching also at the University of California, Davis, and other institutions. David Pines was active throughout his life, and for me, too, it was a rare honor to have such a role model. His forward-looking attitude sometimes caught me by surprise, such as when I learned that he was preparing a 10-year research plan, just as he turned 90. It is indeed unfortunate that the 10-year plan was terminated prematurely. Having already lost a mentor in the world of economics with the death of Lionel McKenzie in 2012, the departure of yet another mentor in interdisciplinary research was all the more poignant.

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