

K y u r i z u k a i

新版

# 窮理図解

2020 March  
no.

33

Bulletin of Keio University Faculty of Science and Technology

<http://www.st.keio.ac.jp/kyurizukai>

English versions are also available:

<http://www.st.keio.ac.jp/kyurizukai/english/index.html>

## Human factors

from Keio's the Faculty of Science and Technology

From elementary particles inside atoms  
to supernova explosions

# Miwa Nakanishi

Associate Professor

Department of Administration Engineering



# Designing products and safety based on knowledge of human characteristics

## Pursuing ideal conditions for humans through engineering

The human palm is generally about 17 to 19 cm in size, and this has been made the standard for deciding smartphone sizes. In addition to physical size, there are many other characteristics that are common to humans in the physiological, cognitive, and psychological aspects. Nakanishi researches how to apply these human characteristics when creating products and services, managing safety, etc., from an engineering perspective and makes outstanding proposals to the real world.

### UX (user experience) sought by products and services

Human factors is an academic field that attempts to deeply understand the physiological, cognitive, and psychological aspects of human characteristics shared among people to propose better designs for tangible and intangible products. There are two main research themes at Nakanishi's laboratory: "UX," which supports lifestyle, and "safety management."

One important keyword when creating products and services is UX (user experience). "In the past, functional aspects such as "functioning properly without errors, achieving the objective faster, etc., were desirable as key values, but as a result of all manufacturers

pursuing these values, it has become harder to differentiate products and services from this perspective. Today, it can be said that there is a need to realize various experiences for the user (UX), such as a sense of accomplishment or psychological adaptation," says Nakanishi (figure 1).

One factor of UX is "attachment." Nakanishi says that "products with attachment bring joy and richness to our lives." In fact, car and consumer electronics manufacturers are striving to create brands that are loved. So, how can products that foster attachment be created?

### The science of "attachment"

Nakanishi has been attempting to understand the psychology of "attachment to products" and root these into products. The first thing she did was to construct a measure to quantify "attachment." Examining the physiological responses of people when they look at objects to which they have strong attachments, she statistically confirmed that the concentration of oxyhemoglobin in specific brain regions increases and the finger plethysmogram (volume fluctuations in fingertip blood vessels)

amplitude becomes smoother.

The British psychologist John Bowlby's "attachment theory" was adopted as a guide to understand the psychology behind attachment. According to this theory, attachment has 4 functions characterized by "proximity maintenance," "safe haven," "separation distress," and "secure base." By supplying these 4 functions in a well-balanced manner, the formation of attachment can be prompted (figure 2).

Taking an ordinary "eraser" as a test object, Nakanishi carried out an experiment, considering interactions with the user to prompt these 4 functions. Specifically, procedures were put in place so that messages such as "nice to meet you" or "please write your name" were sent from the eraser to the user through a smartphone app.

When changes in the cerebral blood volume and finger plethysmogram were measured between the group that used and didn't use the app 30 days, 60 days, and 90 days after the start of the experiment, it was found that the group using the app had a greater attachment to the eraser. The outcomes of this research are being put into practical use through joint research on "speaking home appliances" with a company.

### Thinking of ways for things to "go well" in safety management

Using human characteristics in this way is also useful in safety management. For example, safety in aviation greatly depends on the responses of the flight and ground crews in addition to the performance of the aircraft. "The current trend in safety management research is to clarify how humans should behave for a complete system to function well and what the conditions for this are," says Nakanishi.

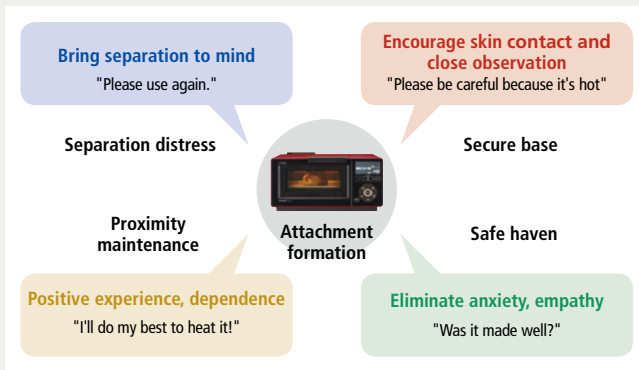
When working in a high-risk situation, it is difficult to make judgements on site. Although "safety first" is specified in manuals, upon what, for example, should rescue workers at a scene of a fire base their judgement on whether or not they should run into a fire to save lives, and if they do, how great the risk will be to their own lives?

"People whose job involves saving lives

Peaceful experiences	01. Having abundance
	02. Feeling at ease
	03. Reliable
	04. Nostalgic
Connective experiences	05. Helping someone
	06. Understanding each other
	07. Feeling attachment
Self-fulfillment experiences	08. Achieve a sense of accomplishment
	09. Enhancing of abilities
	10. Feeling of superiority
	11. Trustworthy
	12. Do as one wants
Caring experiences	13. Physically comfortable
	14. Get a taste of luxury
	15. Attentive
Feel right experiences	16. Just right
	17. Good
	18. Beautiful
Mood-lifting experiences	19. Having expectations
	20. Be overcome with laughter
Special and limited experiences	21. Fresh
	22. Original
	23. Beneficial
	24. Own

Fig.1 24 types of UX (user experiences)

Surveying 2556 ordinary users about valuable experiences they gained through life with home appliances, it was found that they could be classified into 24 UX types. Similarly, a survey of 616 ordinary users on valuable experiences they gained through life with a car found types of UX that were almost the same. It is therefore thought that UX in people's daily lives can in general be explained universally through these UX categories. Based on the design factors of home appliances and cars, in this research, an evaluation method to calculate the probability of each UX being created was established, and these are being shared with home appliance manufacturers and manufacturers in the automotive industry.



**Fig.2 Attachment theory in practice**

Through an attachment formation strategy with the "4 functions of attachment" as axes, products that can provide psychological value to users over a long period of time are proposed. Example: This is used in the audio guide built into a microwave grill (RG-HS1) manufactured by Mitsubishi Electric Corporation.

becomes greater than 6, switching to resilience mode increases the chances of success (figure 3). This means that when a situation is about 6 times worse than normal, better outcomes can be attained by acting resiliently as the circumstances dictate rather than by following steps as outlined in the manual.

### Human characteristics are universal

What motivated Nakanishi to engage in this research was a comment that was voiced at a site, saying "things don't necessarily go well just because you follow the instructions in the manual, but resilient judgements are also difficult to make." At sites where failure is unacceptable, there is a great deal of pressure on taking actions for which judgments have been intentionally made that are not in accordance with the manual in the hope of reaching a successful outcome. "I don't think that we can quantitatively understand everything, but resilience is a human characteristic, and I believe that we can make suggestions to a certain standard. The reason for this is because, on the whole, human characteristics should be universal," says Nakanishi. This outcome, which will be presented soon in a paper, will support judgements made on sites, and furthermore, will contribute to management functions at organizations.

From enriching our everyday lives to supporting social systems, human factors is expected to make various contributions to society.

(Interview and text writer: Yuko Hiratsuka)

do not work just thinking about safety. In their work, there is a trade-off between efficiency and thoroughness. I think 'safety first' means ultimately being able to choose safety without hesitation in these tight and difficult situations."

For this, she says that it is necessary to not only consider "accident prevention" to eliminate failures, but also to investigate how things should be done such that things go well (and safely), and carry out studies with the goal of increasing such cases. "If safety is secured by restricting your actions, then not flying or not rescuing people when fires break out would be the safest course of action. To keep this from happening, I want to study how things should be done for them to go well and through this, support those working on site."

### Indicating the time to go beyond the instructions "outlined in the manual"

At the worksite, people acting in accordance with a set procedure (manual) is a basic premise. However, when a situation that cannot be dealt with in accordance with a manual arises, flexibility (resiliency) is required to make judgements. At what point should you switch from following the manual (manual mode) to making your own judgement (resilience mode) to ensure

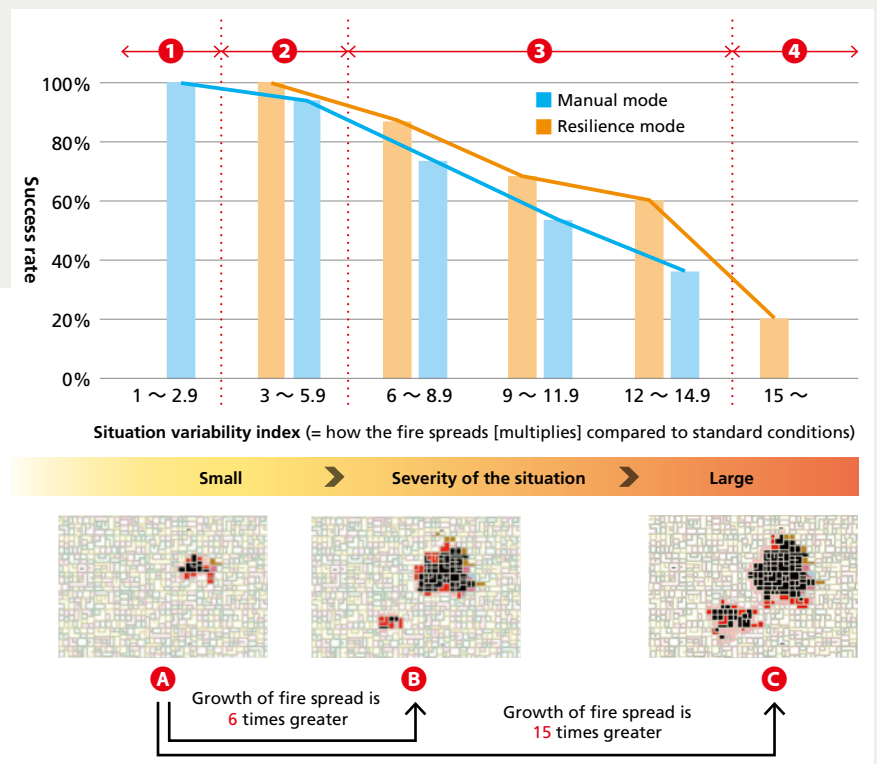
a high probability of success? Can a scientific approach be taken to reproduce the ability to make these judgements, nurtured through experience gained and intuition developed on site?

Taking a fire scene as an example, Nakanishi carried out simulation experiments. By making various changes to the wind speed, wind direction, and firefighting resources (water, fire trucks, equipment, personnel), different situations were created. As the fire progressed and the situation worsened in these simulations, she noted the point at which the subjects switched from manual mode to resilience mode to extinguish the fire, and whether they were successful or not.

Taking the area a fire spreads in 30 seconds under conditions of calm winds and sufficient firefighting resources as 1, how bad a situation is when conditions change (situation variability index) can be expressed in terms of how many times greater the area in which the fire spreads is in the same span of 30 seconds. From the results of this experiment, it was found that when the situation variability index

**Fig.3 Simulation experiment to observe human decision-making by modelling fire scenes**

- ① It is fundamental to follow the manual under standard conditions.
  - ② Acting in accordance with the manual gives satisfactory results.
  - ③ When the situation is 6 times worse than standard conditions, a resilient response that is not in the manual will increase the success rate.
  - ④ When the situation is about 15 times worse than the standard condition, success will be difficult whether the manual or resilient response is adopted.
- A When the wind is calm (3m/s or less) and sufficient firefighting resources are available during initial firefighting.
  - B When the spread of fire grows, winds become stronger (7 m/s on average), and fire trucks are delayed due to heavy traffic.
  - C When the spread of fire grows even more, winds become stronger (11 m/s on average), and fire trucks and equipment have been depleted.





## Knowing the site, seeing the site

Considering various things about the people related to the research theme. Is the only essence of life being able to do work quickly and without making mistakes? What kind of difficulties do pilots and firefighters face while doing their jobs, and what do they find fulfilling? What Nakanishi, who wishes to help solve the specific problems people have through engineering, cares most about is listening to the voices of people at sites.

### What kind of child were you when you were young?

I haven't changed much since I was a child. I was like I am now. From elementary school to senior high school, I was "the first" to raise my hand to ask questions during class. I acted freely. My parents and school teachers were always saying "do what you want with confidence" to me while I was growing up, so I have always been thinking about things on my own and doing what I found interesting.

### What motivated you to study human factors?

The way the words sound. The words "human factors." I found it very interesting to be able to engage with human beings in the field of engineering, which creates products and solves issues scientifically.

The actual human factors I learned at university, however, was different from what I had expected in a good way. Humans are affected by every environment in their surroundings, which changes their state of mind, and this alters their performance. I learned that it not only involves physical characteristics such as comfortable beds and easy-to-write pens, but that psychological and cognitive characteristics are also heavily involved.

Afterward, you carried out research at the Division of Design Science at Chiba University.

Many students there hope to be designers, and they worked very hard to create something attractive. They didn't seem to be all that interested in understanding why their designs were attractive or good, or clarifying its significance. While interacting with these students, I was secretly thinking that in addition to being a good seed for research.

### That led to your current research.

When a home appliance manufacturer is making a new product, even if the designers present novel ideas, it is often the case that the final version, turns out to be a product that is restored to something that is not all that different from the previous model. This is because even if there is a measure to quantify "whether or not something can be used without a doubt," there is no measure for quantifying "attractiveness" or "impressiveness." However, this is something that users are actually looking for today, and in the introduction of my research (page 2), an example of a product that incorporated "attachment" into the design is presented.

### Can it be called research conducted from the perspective of the user?

Yes. In the field of human factors, social needs change with the times, so it is necessary to propose solutions that take these changes into consideration. Human characteristics may be





universal, but where they are applied to is constantly changing.

Changes in where they can be applied is not limited to the times. Even if you take the same period and the same type of occupation, the circumstances of each one will be completely different. In this sense, what I value the most in my research is "knowing the site and seeing the site."

The other day, I was hung from a hoist used for rescues by firefighters, and I have also been to airport control towers all over the place. I always want to see the site and understand what people there value as much as possible, and I try to make this part of my research.

### Please tell us about the good qualities of Keio University, which is also your alma mater.

I would say teammates. Back when I was a student and now working as a faculty member, everyone is a good senior and junior member, and there is an environment in which we can improve together by learning from each other.

Additionally, one of the things I find really great about working at Keio is that I not only get to work closely with other faculty members, but also with the administrative and technical staff members on a variety of tasks. Up to now, I have experience of working at 3 universities including Keio, and I am proud that it is this kind of teamwork that is the great strength enabling Keio to

take on new challenges one after another.

### Please give some advice to the students.

I myself was always told "do what you want with confidence," so I also often say this to the students.

In my lab, students call me "Nakanishi san." Although I am the research leader, there is quite a lot I learn from my students. I want them to keep breaking ground in their area of expertise by themselves.

### ◎ Some words from students ... ◎

● There is a lively atmosphere in the lab. Whether Nakanishi is here or not, we all go together to eat lunch. I can feel that Nakanishi is consciously making efforts to create this good atmosphere for us. If there is good communication among the members in the lab, your research will also go smoothly. (2nd-year master's student)

(Interview and text writer : Yuko Hiratsuka)

For the full text of this interview • .....

<http://www.st.keio.ac.jp/kyurizukai>

## Do what you want with confidence. Amicably and enjoyably carry out top-class research.

### Miwa Nakanishi

Specializes in human factors. Investigates the possibility of solving or easing on-site problems and creating new added value from the perspective of human factors. Graduated from the Keio University Faculty of Science and Technology, Department of Administration Engineering in 2000. Completed the doctoral program at the Keio University Graduate School of Science and Technology in 2004. Ph.D. in engineering. Assistant Professor at the Tokyo University of Science Faculty of Engineering, Department of Management Science from 2005. Assistant Professor at the Chiba University School of Engineering, Division of Design Science from 2008. Assistant Professor at the Keio University Faculty of Science and Technology, Department of Administration Engineering from 2010. Current position since 2014.





### Japan Transport Safety Board

As one of her external activities, she participates as a member of the Japan Transport Safety Board (Aircraft). Their mission is to investigate the cause of accidents and major incidents involving aircrafts, and examine how to prevent these from reoccurring. She takes part in these activities from a human factors perspective. It can be said that human factors developed together with aviation safety, and while working for this board, there is a lot she learns from actual incidents. She also considers it to be a setting where there is a great obligation to pass on knowledge and research from human factors.

The photograph on the left was taken during a panel discussion of the commemorative symposium to mark the 10th anniversary of the establishment of the Japan Transport Safety Board (with the merger of the Aircraft and Railway Accidents Investigation Commission [ARIC] and the cause-identification section of the Japan Marine Accident Inquiry Agency [JMAIA]), at which she struggled to manage the time and had to graciously interrupt influential members while they were making statements. The photograph on the right is from a hike she went on to Mount Osutaka during the summer to pay her respects to those who died. (Japan Airlines Flight 123 crashed there on Aug. 12, 1985)



## Miwa Nakanishi's ON and OFF

Always doing her best for everything.  
Work and play are fun because they're done in earnest.



### While attending an international conference...

The photograph above was taken in Poland (Kraków). The photograph on the right was taken in Italy (Venice). One of the things that motivated her to get into this line of work may have been the many opportunities to travel abroad. She occasionally meets students who graduated from her laboratory, and while at international conferences, there are many chances for them to laugh and recall the past, talking about how things and people were.

### Everyone eats lunch together

In general, everyone in her laboratory goes to eat lunch together at the cafeteria. Even if the members were having heated discussions at seminars until moments before, during lunch, all this is forgotten and instead, conversations on topics such as professional baseball, idols, and family are had. She hopes that her laboratory will be a place where the students meet people with whom they will become friends for life (just as it was for her).



# 私の 本棚

My favorite books



## ● Books by Yukio Mishima

When she was a child, a mobile library (a small bus with bookshelves installed inside) would visit her neighborhood, and she enjoyed borrowing books that caught her attention up to the maximum number permitted. Even today, she instinctively chooses books to read at random, and she gives the books to someone else when she's finished with them. She mentions Mishima's books here just because she happened to have one at hand, but she likes Mishima's writing style.

## ● Imagine like an Amateur, Execute like an Expert

She picked up this book for no special reason while she was a graduate student, but even today in her research activities, her stance is the same as that of the title of this book. In the field of human factors, there are many research themes that require being in close contact with the actions of living people in their actual daily lives and workplace, and in this sense, it is better if ideas are easier to understand. On the other hand, as there are in general no theoretical techniques in this field, the challenge is to rationally apply knowledge and techniques from other fields such as computer science, statistics, psychology, and physiology according to the theme. Often, it is necessary to deal with knowledge and techniques of these other fields with specialized techniques for the issue at hand with the intuition to read data. She also frequently quotes the title of this book to encourage her students. Another thing she regularly says to her students is "never put off till tomorrow what can be done today."

## ● Human factor

This is an old book, originally written in 1987, but even today, she finds "Human factor" enjoyable and reads through the book. It goes without saying that aviation safety today is extremely high, but this is not only because of the advancements in aircraft systems. It is also because of developments in human factors that underpin this, including the pilots and flight attendants, air traffic controllers, and other ground staff. This book is a reminder of this fact.

## ● Pensées by Pascal

This is the most important book in her life. As you know, Pascal was a mathematician and physicist known for conceiving Pascal's theorem, but at the same time, he was a philosopher and theologian who deeply examined the essence of the existence of "human beings." A well-known phrase in *Pensées* is "man is a thinking reed," but her favorite part of the book is the phrase that just precedes this: "Man is only a reed, the weakest in nature." Human factors research often seeks to understand humans using powerful scientific and technological tools, but on the other hand, the fact that humans are unstable entities swaying from side to side in nature and thus cannot be essentialized and explained through the principle of causality is also kept in mind.

This is why she wants to see and hear actual situations of people working to make daily life and work life better, including their instabilities, on site, and carry out research that will help them by providing them with a means to overcome the actual issues they experience, and take a step forward.

Furthermore, although she herself is a weak person who is inclined to be tilted by strong winds or swept away by large waves, she wishes to work with confidence while getting to know this aspect of herself better. This is an important book that teaches such lessons and gives her hope.

## ● The design of everyday things

She came across this book at the Hiyoshi Library while she was taking a human factors course as an undergraduate student. Read this book to understand well why the field of human factors deals with both of the seemingly different topics of product design and industrial safety. There are mixed reviews on Norman's interpretations, but this book is a good entry point for those interested in this field.

## An engineering approach for humans

Miwa Nakanishi

Have you seen the movie "Sully"? It is based on a true story of US Airways flight 1549, which in 2009 encountered a bird strike shortly after taking off from an airport in New York, causing both engines to shut down. By making decisions without delay and with his highly skillful flying, the captain landed the aircraft in the Hudson River. All passengers and crew members on board survived.

Because it's a real story, a little more of the movie will be revealed. Members of the National Transportation Safety Board (NTSB), who conducted the investigation of the incident, point out that instead of making

the dangerous decision of landing the aircraft in the river, the captain and first officer should have returned to the airport they took off from in accordance with guidelines or alternatively, landed at another airport nearby, showing data from computer simulations that it was physically possible to do so. However, Tom Hanks, who plays the role of Captain Sullenberger clearly states that "you still have not taken into account the human factor."

Every day, people live their lives in the real world, intricately taking into consideration many factors including information obtained through their 5 senses, past experiences, self-evaluations, beliefs, and values, and make decisions for the next moment they face. This of course takes time, and the probabilities of the decisions being good or bad will be different from those computed upon review.

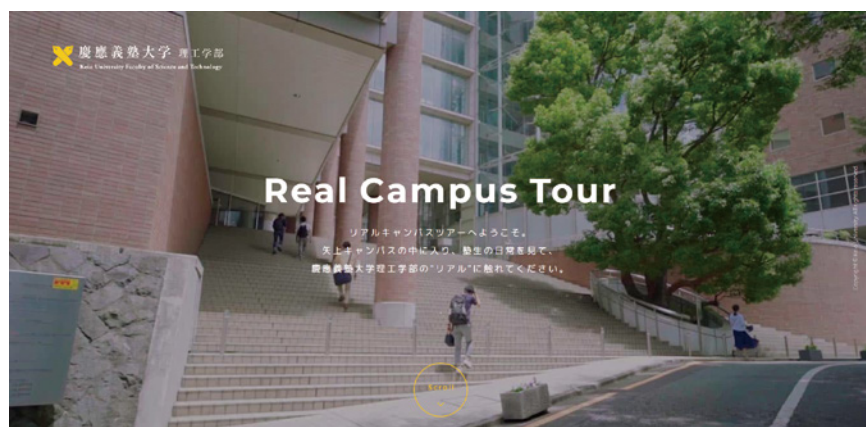
With scientific and technological developments, the measurement technology

of individual signals and methods to predict and evaluate an unknown using measurements taken as parameters have been advancing considerably. Looking back, however, the world may be valued only through factors that can be measured at the time. Above all, it may be that what humans are actually thinking and doing cannot really be expressed using existing measures. And neither can decisions made by pilots during emergencies or the trivial choices we make in our daily lives.

What kind of measure can we use to capture human factors, and how can these be applied to human society that functions in this way today? It is because of the very fact that the use of automated systems and AI have become more prevalent nowadays, that I believe the new mission of examining actual humans from an engineering perspective is further expanding.

## 理工学 Information

### Experience campus life at the Faculty of Science and Technology (Real Campus Tour)



A special site, "Real Campus Tour," for taking a tour of Yagami Campus where the Faculty of Science and Technology is located has been established on the faculty's official website, which can be accessed from your device.

The "Real Campus Tour" can be accessed not just from Japan but anywhere in the world, 24 hours a day, to view the atmosphere within Yagami Campus for a variety of activities, including research, student life, and the laboratories. Please experience student life at the Faculty of Science and Technology for yourself just by using your device.

### Editor's postscript

Members of Nakanishi Laboratory eat lunch together every day at the school cafeteria. While taking pictures at the laboratory, all members were happily talking to each other, and it was felt that everyone, including the teacher, gets along well. It was very interesting to hear Associate Professor Nakanishi's story, who herself places great importance on visiting sites and communicating with people, and her story was listened to attentively.

(Izumi Hagiwara)

**Cover of current issue :** In front of a flight simulator indispensable for carrying out research for "managing safety in aviation," one of the themes of this issue.

Access Real Campus  
Tour from here



Check information on the Faculty of Science and Technology on Twitter and Instagram



Official Twitter  
page of the  
Faculty of Science  
and Technology



Official Instagram  
page of the  
Faculty of Science  
and Technology

新版 窮理図解



New Kyurizukai  
No. 33 March 2020

Editing: "New Kyurizukai" Editing Committee  
Photographer: Keiichi Muraguchi  
Designers: Hiroaki Yasojima, Yukihiko Ishikawa (GRID)  
Cooperation for editing: SciTech Communications, Inc.  
Publisher: Eiji Okada  
Published by: Faculty of Science and Technology, Keio University  
3-14-1, Hiyoshi, Kohoku-ku, Yokohama, Kanagawa 223-8522  
For inquiries (on "New Kyurizukai" in general):  
kyurizukai@info.keio.ac.jp  
For inquiries (on industry-academia collaboration):  
kl-liaison@adst.keio.ac.jp  
Website version:  
https://www.st.keio.ac.jp/education/kyurizukai/