Fostering Cross-cultural Research by Cross-cultural Student Teams: A Case Study Related to Kawaii (Cute) Robot Design

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Abstract. As robotic gadgets, and eventually robots, become increasingly common in daily life, it is critical that roboticists design devices that are accepted across cultures. Previous studies have examined cross-cultural differences in robot acceptance based on various design characteristics. Similarly, prior studies have examined cross-cultural perceptions of kawaii (Japanese cuteness). Building on these two prior research strands, this paper reports on our developing approach, with support from a United States National Science Foundation (NSF) International Research Experiences for Undergraduates (IRES) grant, to use a cross-cultural, faculty-student design team to gain a deeper understanding of the role that kawaii (Japanese cuteness) plays in fostering positive human response to, and acceptance of, robotic gadgets across cultures.

After explaining the motivation for the work, we outline our approach from both a technical and educational perspective. In doing so, we provide a case study that demonstrates how a cross-cultural design team involving students can simultaneously generate new knowledge and provide research training for future Human Computer Interaction professionals.

Keywords: Human-robot Interaction, Cross-cultural design, Kawaii.

1 Introduction and Motivation

1.1 Kawaii

The word kawaii stemmed from the word *kawayushi* that appeared in *Konjaku Momogatarishu* (Tales of Times Now Past) in classical Japanese literature [1]. At this time, the word kawaii meant pitiful, shameful, or too sad to see [1]. Over the course of Japanese history, the meaning of the word evolved to describe the small, weak, and someone or something that invokes the feeling of "wanting to protect" [1]. More recently, the meaning of kawaii has been extended to the concept of "Japanese cuteness." Indeed, in their book "Cuteness Engineering: Designing Adorable Products and Services" Marcus, Kurosu, Ma and Hashizume confirm that kawaii is the closest Japanese word to the

English word cute [2]. In this modern context of cuteness, the notion of kawaii is now pervasive in Japan and can be seen in designs ranging from Hello Kitty products to road signs to robotic gadgets, to name just a few examples.

Increasingly, kawaii design principles are incorporated into successful products that are used globally including robotic gadgets [3, 4]. An object's kawaii-ness is an important part of its affect, and may influence a user's acceptance of the object. Therefore, when designing products, such as robotic gadgets, for global use, it is important for designers to understand how specific groups of target users perceive and relate to kawaii.

1.2 Related Work

Previous studies have examined cross-cultural differences in robot acceptance based on design characteristics. For example, researchers have documented the impact of localizing a robot's greeting style (gestures and language) on acceptance by Japanese versus Egyptian users [5] and other studies have obtained similar results varying only robot gesture styles across users from Japan, China, Thailand and Bangladesh [6]. In another study, differences in likeability of robots were found between Chinese, Korean and German users based on variations in the robot's appearance [7].

Similarly, a number of studies, including studies by the authors, have examined perceptions of kawaii including differences in perceptions across cultures and genders. For example, third author Ohkura and her collaborators have found gender differences in preferences for various kawaii spoon designs based on shape, color and geometric pattern [8]. In a broader study, Hashizume and Kurosu examined the extent to which perceptions of kawaii in 225 photographs differ between male and female Japanese college students [9]. The photographs were divided into subgroups including products, objects, foods (see Fig. 1.), geometric shapes, animals, characters and people.

Fig. 1. Japanese Sweets

Gender differences were established, depending on the subgroup of object studied. For example, male subjects found spherical geometric objects to be more kawaii than female subjects [9]. In collaboration with Hashizume and Kurosu, first author Berque and second author Chiba extended the original study by presenting 217 of the original 225 images to American college students and gathering data about their perceptions of kawaii-ness in each image. Differences were found in a variety of images, particularly between Japanese males and American males as well as between Japanese females and all other groups [10].

Prior work that investigates the role of kawaii in user perceptions and user acceptance of robots or robotic gadgets is limited. One pair of papers reports on studies of kawaii-ness in the motion of robotic vacuum cleaners [11, 12]. The authors programmed a visually plain Create robot (a programmable version of a Roomba vacuum cleaner) to move according to 24 different patterns, including patterns that the authors describe with terms such as bounce, spiral, attack, spin and dizzy [11, 12]. While subjects did not judge the static robotic vacuums to exhibit kawaii-ness, most subjects did consider the vacuums to exhibit kawaii-ness when they made specific rotational motions such as a spiral [11]. These studies demonstrate that kawaii-ness can be expressed through motion even in the absence of more traditional visual kawaii-ness; however, the studies did not consider cultural or gender differences.

Increasingly, Japanese robots are being designed with kawaii-ness principles in mind. As an example, consider Sony's Aibo robotic companion dog (see Fig. 2, which depicts an Aibo cuddled with a ball). Many people find Aibo to be kawaii; however, it is not clear which features (size, shape, sound, motion) of Aibo evoke this feeling and it is not clear if the key features vary across genders or cultures.

Fig. 2. Sony Aibo cuddled with a ball

1.3 The NSF International Research Experiences for Students Program

The International Research Experiences for Students (IRES) program is one of many programs supported by the United States National Science Foundation (NSF). As described by the NSF, the program supports "…international research and research-related activities for U.S. science and engineering students." [13] The NSF further explains that the program "contributes to development of a diverse, globally-engaged workforce with world-class skills. IRES focuses on active research participation by undergraduate or graduate students in high quality international research, education and professional development experiences in NSF-funded research areas." [13]

The IRES program consists of several tracks and this paper describes a proposal that falls under a track which must provide a cohort international research experience for a group of students. Although each student should have a specific role on the research team, the research experiences must have a single intellectual theme that is aligned with an area that the NSF supports. We organized this project, which we describe in the remainder of this paper, around developing a better understanding the role that kawaii (Japanese cuteness) plays in robot design.

1.4 Project Overview

In the remainder of this paper, parts of which are adapted from our IRES proposal, we describe a collaboration between DePauw University in the United States and Shibaura Institute of Technology (SIT) in Japan. The collaboration is supported by a three-year $286,761 National Science Foundation IRES grant entitled "Involving Undergraduates in Research on Design and Cross-Cultural Perceptions of Cuteness in Robotic Gadgets." The NSF grant provides funding for 12 DePauw students (four per summer in 2020, 2021 and 2022) to spend seven weeks in Japan collaborating with faculty and student researchers at SIT.

From a technical viewpoint, the grant is enabling us to investigate cross-cultural and gender differences related to perceptions of kawaii in robotic gadgets, with the aim of informing the design of robotic gadgets that are accepted across cultures. In parallel, this work provides a case study that demonstrates how a cross-cultural design team involving students can generate new knowledge while simultaneously providing research training for future Human Computer Interaction professionals. We believe a similar two-pronged approach can be taken by other HCI researches and educators by engaging cross-cultural student teams in studying cross-cultural research questions and we intend for this paper to provide a case study that can be adapted by others.

2 Research Methodology

2.1 Example Project Domains

We present two example research project domains that can provide context for the IRES robotic gadget prototypes, although additional domains will be explored. The first example domain centers on the design and evaluation of prototype kawaii robotic vacuum

cleaners for use in a home environment. As mentioned previously, prior work has investigated user perceptions of kawaii-ness based on movement patterns of robotic vacuums [11, 12]. While this work established that users can perceive kawaii-ness based solely on motion, the results are limited in a number of ways. First, the work does not consider differences across culture or gender. Second, the work does not incorporate other common kawaii attributes such as colors, geometric shapes, child-like or animal-like qualities, and sounds. Using the Wizard of Oz technique, IRES students will design and prototype robotic vacuums that incorporate kawaii-ness through their appearance, or by making sounds or changing expression upon bumping into an obstacle. These kawaii visual, motion-based, and auditory attributes can also be combined synergistically.

The second example domain centers on the design and evaluation of prototype robotic gadget companions/assistants for college students. As early as 2003, Fogg proposed what he then considered to be a futuristic "study buddy" that would assist students by prompting them to adopt good living and study habits and by providing other helpful information [14]. What seemed futuristic in 2003 is now realistic. In the past year, several schools have begun providing all students with Amazon Echo Dots that use Alexa to equip every student dorm room with a student assistant service, customized with campus-specific information [15]. The service is helpful in some ways; however, user reception has been mixed due to privacy concerns [15]. We will build prototypes of novel robotic gadget student assistants that exhibit various forms of kawaii-ness to understand the role that kawaii can play in user-acceptance of these gadgets. IRES students will be particularly well-equipped to the creative design of these prototypes because they will have a good understanding of how this type of technology can be matched to the needs of a college student.

2.2 Cross-cultural Evaluation Approaches

There are well-established approaches to determining a user's emotional reaction to an object, including self-reports, external measures such as analyzing facial expressions, and internal measures such as using biosensors to measure brainwaves (EEG) and heart rate (ECG). Advantages and disadvantages of these techniques are delineated in the literature (see, for example, [16] as well as prior work by fifth author Sugaya [17]). As explained below, we will use both self-reports and biosensors in the IRES project.

One challenge in running a cross-cultural, multi-site user study involving prototypes of robotic gadgets involves replicability. It is difficult to build several identical prototypes for use at different sites and even more difficult to build several versions of each prototype that incorporate different kawaii properties. Therefore, we will explore the use of traditional video, as well as stereoscopic 3D video, to record each prototype and to present the prototype consistently to users at different sites.

Presenting the robotic gadget prototypes via video brings the added benefit of allowing us to use the Wizard of Oz Technique to run our studies. Specifically, rather than building fully functioning robotic gadget prototypes, the prototypes only need to have enough functionality to make a convincing video. For example, a robotic gadget that

looks like it is taking an action in response to a human stimulus, or in response to bumping into another object, may actually be responding to a command given by an off-camera human operator.

Each student will work on a project that involves prototyping several versions (with varying degrees and types of kawaii-ness) of a domain specific robotic gadget, and then conducting one or more experiments from our user-study suite.

Across domains, research will follow the following general methodology:

1. Consider the relevant kawaii literature and discuss with SIT faculty mentors.
2. Design and prototype multiple versions of robotic gadgets in the given domain with varying degree and types of kawaii. Feedback will be provided by the SIT faculty mentors throughout the design and prototyping stage.
3. Create traditional and, or stereoscopic 3D videos of the prototypes in action.
4. Conduct one or more of the user studies using appropriate measures (e.g., Self-Reported Kawaii, Measured Internal Joy, Self-Reported Acceptance) under the guidance of the SIT faculty mentors. For example, comparing Measured Internal Joy to Self-Reported Acceptance across cultures.
5. Analyze results and iterate as appropriate.

When cross-cultural user studies are required, data will be gathered from Japanese participants at SIT and from American participants at DePauw University. User studies will first be run at SIT under the guidance of the SIT faculty mentors and then will be replicated at DePauw.

3 Student Preparation for Cross-cultural Experience

3.1 Student Recruitment

Students will be recruited from DePauw University Computer Science Majors. We expect students to participate in the IRES program during the summer following their sophomore or junior year.

Students must have completed, or have a plan to complete, core computer science course-work including courses in Data Structures, Object Oriented Software Development, and Computer Systems prior to departure for Japan. Coursework related to Japanese language and/or culture will strengthen a candidate's application.

3.2 Pre-departure Technical and Cultural Preparation at DePauw University

Prior to departure, students will be encouraged to enroll in relevant computer science and Japan-related courses such as Human Computer Interaction, Japanese Language, and Japanese Art History. Table 1 shows the relevant courses that will have been completed by each of the students who are participating in this project during the summer of 2020. We believe that the balance of technical, language and cultural preparation will prepare the participants to engage in a cross-cultural design experience.

The first and second authors will meet regularly with the IRES students in the months prior to departure in a workshop series that will provide an introduction to: Japanese culture, Japanese customs and etiquette, Japanese design principles including traditional aesthetic concepts as well as kawaii, the role of robotics in Japan, the benefits and challenges of working on cross-cultural teams, and research ethics. As part of the workshop series, the students will also use DePauw's Tenzer Technology Center to learn how to make stereoscopic 3D videos and to learn the basics of the programming environments they will use at SIT.

Table 1. Technical, Japanese Language and Japanese Culture Background of Participants

Student	**Computer Science Courses**	**Language and Culture Courses**
Student 1	Computer Science I; Data Structures; Object Oriented Software Development; Computer Systems; Foundations of Computation; Data Mining; Artificial Intelligence; Database and Filesystems.	Three Years of Japanese Language; Introduction to China and Japan Early Modern and Modern Japanese Art; Readings in Asian Studies; Japanese Culture, Technology and Design; Warrior Art of Japan; Advanced Readings and Projects in Japanese.
Student 2	Data Structures; Computer Systems; Object Oriented Software Development; Writing in Computer Science.	Three Years of Japanese Language; Introduction to China and Japan; Japanese Culture, Technology and Design; Martial Arts Intensive; Supernatural in Japanese Art.
Student 3	Computer Science One; Data Structures; Object Oriented Software Development; Foundations of Computation; Computer Systems.	One Year of Japanese Language.
Student 4	Computer Science One; Data Structures; Object Oriented Software Development; Computer Systems; Foundations of Computation; Artificial Intelligence; Computer Networking.	One Year of Japanese Language; Japanese Culture, Technology and Design.

The students will also be introduced to the LINE social media system. This is the most popular messaging and social media system in Japan [18] and will be indispensable to the students in Japan. LINE's is itself an example of kawaii design and the first two authors have published about the use of LINE to introduce kawaii to American students and to enable student communication during an American travel course to Ja-

pan [19]. The cohort will use LINE to communicate with each other and with the faculty leaders so they can experience kawaii design and to prepare them to use the tool, including its language translation features, in Japan.

DePauw enrolls more than twenty Japanese students and a few of them will meet with the IRES students, as well as participate in the LINE discussions, to offer their perspective on Japanese culture. The SIT faculty mentors will also join a few workshops (virtually, via LINE) to introduce themselves and to provide information about specific research projects. In addition, in years two and three of the IRES program, students who participated in the program in the prior year will attend a workshop to share their experiences.

IRES students will attend a session that DePauw's off-campus study offers students who are preparing to study abroad. These sessions cover Identity Abroad, Integrating International Experiences into Career Planning, and Health and Safety Abroad.

As shown in Table 1, each IRES student brings different experiences to this program. For example, some students know more Japanese language than others and some students have deeper technical knowledge. Each student will be encouraged to use his or her strengths to help other students. In our experience, this approach is as helpful for team-building as it is for building technical and cultural competencies. IRES students will travel to Japan as a team. To assist with travel and acclimation for the first week, the students will be accompanied by DePauw faculty members.

3.3 Technical and Cultural Support at Shibaura Institute of Technology

Shibaura Institute of Technology (SIT) is the ideal site to host the proposed IRES project from both a technical and global learning perspective. SIT is a private technology university with three greater Tokyo area campuses that collectively enroll more than 7,000 undergraduates and more than 900 graduate students. The Institute holds three colleges that each house a cluster of engineering and science departments. SIT is the only private technology university in Japan to be selected for the Japanese Government's Top Global University Project. This project seeks to recognize and enhance Japanese universities that are innovators in internationalizing their educational offerings and reputations. As such, SIT has significant experience in hosting student and faculty researchers for short-term, medium-term and long-term research collaborations. At any given time, SIT hosts approximately 500 international exchange students and the IRES students will benefit from this environment.

The IRES project will be housed in the Department of Information Science and Engineering in the College of Engineering, which is part of SIT's main campus, the Toyosu campus, located in the Tokyo Bay area. This campus is home to junior and senior undergraduate and graduate students in the College of Engineering and is also home to the SIT's Robotics Research Square, which is the base of the Shibaura Institute of Technology Robotics Consortium.

IRES students will have access to the research facilities that are overseen by the SIT faculty research mentors as well as to appropriate departmental resources. These facilities will provide the hardware materials and software tools for building, customizing and programming prototypes of physical-electronic gadgets, such as robot components,

that will be central to this research. The labs also have several Neurosky EEG and ECG biosensors that can be used to gather biological readings from human subjects.

The grant will provide funding (admission tickets, travel expenses) for the IRES students and a roughly equal number of Japanese student lab-mates to take advantage of a number of relevant cultural activities while they are on site in Japan. These group activities will strengthen the local research community. Students will visit Japan's National Museum of Emerging Science and Innovation, which is located in Tokyo. Among the interactive robot displays are the Paro therapeutic robot and Honda's Asimo robot. Students will also visit the Chiba Institute of Technology Tokyo Sky Tree Town Campus which houses a public display of robots including rescue robots. Students will also visit the International Tokyo Toy Show, which takes place each June and showcases thousands of toys, including robotic gadgets.

Because contemporary Japanese design aesthetics are rooted in tradition, students will visit the Edo-Tokyo museum, which showcases Japanese design in the Edo period from 1603 – 1868. Students will also take a weekend excursion to Kyoto, Japan's old capital which is famous for preserving traditional designs, to see historical sites such as castles, temples, traditional handcrafts and the masterful Zen gardens that greatly influenced Steve Jobs's design aesthetic.

4 Conclusion

This IRES project will benefit greatly from a cross-cultural collaboration and is ideally suited to be conducted in Japan due to the strong integration of kawaii in Japanese culture. The synergistic contributions of a research team that includes faculty mentors who have a deep and broad understanding of the Japanese concept of kawaii, working alongside students who understand American culture are nicely situated to tease out subtle differences that may influence differences in perceptions of these two populations. In addition, the cross-cultural team will be well positioned to run user studies with both Japanese and American subjects. The Shibaura Institute of Technology faculty mentors are excited about applying their ongoing investigation of kawaii in a new cultural context, with the help of their American student and faculty collaborators.

This collaboration will advance knowledge related to several scientific and methodological challenges. Robots and robotic gadgets can induce feelings of both fascination and fear, especially when operating in personal spaces such as homes [20]. Researchers have shown that a robot's appearance can impact the degree to which users accept the robot, at least in some contexts [21]. The IRES research will apply previous work that examines perceptions of kawaii-ness in simple static objects to the new context of dynamic robotic gadgets. This work will result in a set of kawaii design guidelines that help designers build robotic gadgets with a kawaii appearance that makes them more likely to be accepted by specific populations.

The research will also explore correlations between several measures that can be used to evaluate a range of robotic gadgets. This work will advance our understanding of the most appropriate measures to use when evaluating robotic gadgets in specific contexts, and for use with specific populations.

Additionally, this research will deepen our understanding of the benefits and limitations of using traditional video and stereoscopic 3D video for studying robotic gadget prototypes in a cross-cultural, multi-site setting. If effective, the use of video will enable other researchers to replicate our studies in different cultural contexts, which will result in a robust dataset.

While each IRES student will be responsible for designing, building and evaluating specific prototypes, the students will employ the same research methodology, which will result in a shared knowledge base. This will enable the twelve student participants over the three-year project to contribute to a research result that is significantly greater than the sum of the contributions made by each student. This approach has the potential to impact the way other researchers design multi-student undergraduate research experiences in computer science.

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