ISSN 1738-8074

International Journal of Asia Digital Art and Design

Vol.20 No.01 2016

Asia Digital Art and Design Association

Contents

Categories for paper

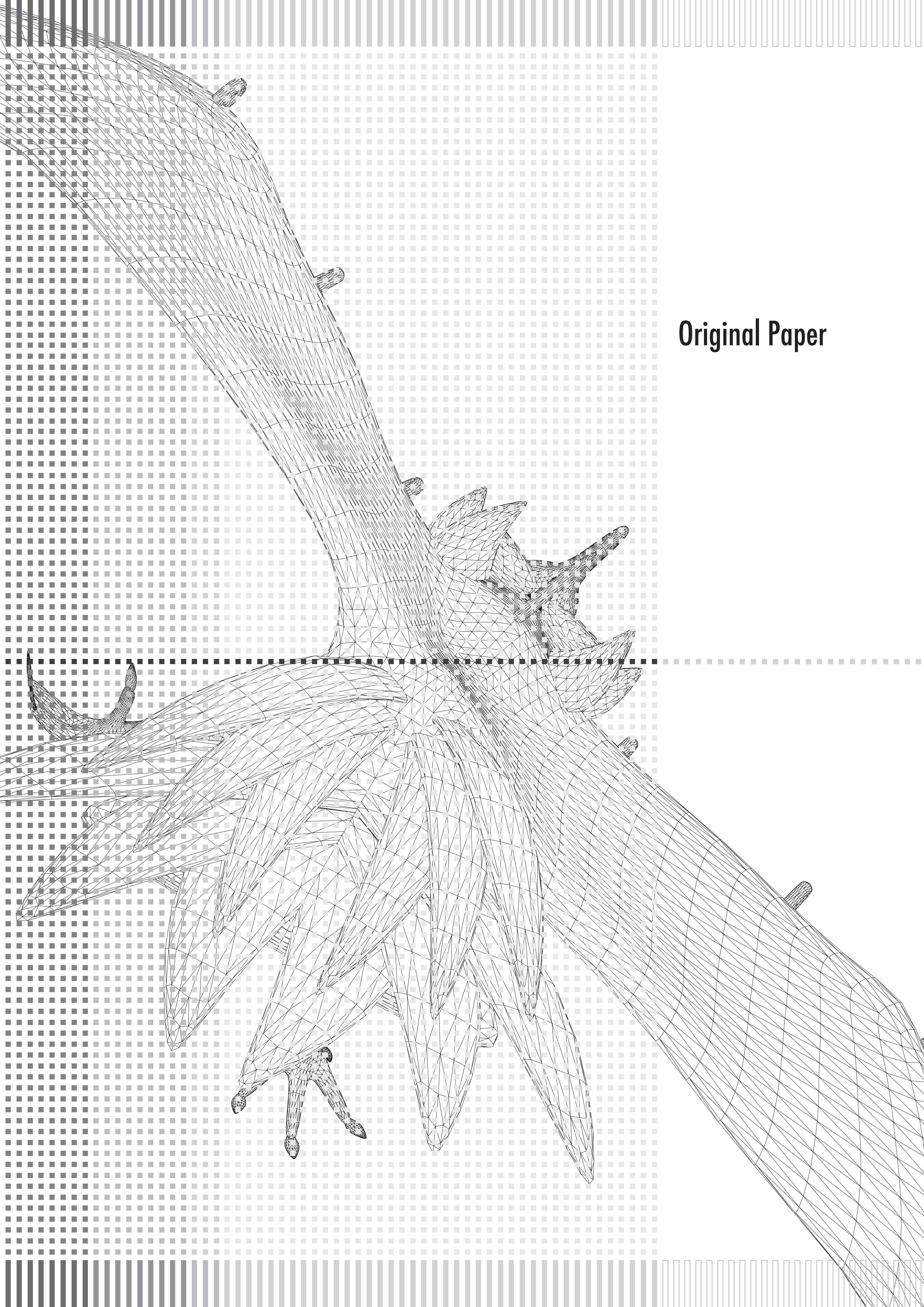
・Original Article

A paper in this category has to be a logical and empirical report of the study, the review and the proposal by the author on the issue of digital art and design based on media technology. It also has to include the novelty and academic values which can be shared with ADADA members or the people who study digital art and design.
Number of pages: 6 -10

・Art Paper

A paper in this category has to consist of the author's practice, result and expository writing on the field of digital art and design. It also has to have the originality in its concepts, methods, expression techniques and making process, and the result should have some values which can be shared with ADADA members or the people who study digital art and design.
Number of pages: 6 -10

Original Paper



Received March 1, 2016; Accepted April 2, 2016

International Journal of Asia Digital Art & Design

A pattern language: designing a hazard information map interface for community-based users

Haimes, Paul
Tokyo Metropolitan University
haimes@tmu.ac.jp

Medley, Stuart
Edith Cowan University
s.medley@ecu.edu.au

Baba, Tetsuaki
Tokyo Metropolitan University
baba@tmu.ac.jp

Abstract
This paper explains guidelines that arose from a collaborative research project that aimed to make map-based bushfire information more accessible to people in remote and regional Australian communities. The MyFireWatch web application was a practical outcome from this research and was the result of several iterations of user and service-provider engagement. This application delivers a web-based interface that works on desktop and mobile devices which displays bushfire locations around Australia in near real-time. As a way of generalising from the work undertaken that resulted in the MyFireWatch application, guidelines were created to inform others working in similar domains. These guidelines are presented here in the form of a pattern language and are intended to inform the design of similar systems. Pattern language has previously been used in architecture, software engineering and interaction design as a means of exchanging knowledge in a way that provides specific solutions to recurring problems, yet these solutions are generalised so that they can be applied in different scenarios. The pattern language described here is intended to encourage others who may be working with map-based hazard information to consider various aspects of the interface and its functionality. It is hoped that in doing so, communities in Australia and beyond will find such systems more accessible, intuitive and easy to use.

Keywords: human factors, user interface guidelines, GIS map applications

1 Background

Landgate – the primary source of geographical data and land information in Western Australia – produces several fire monitoring services derived from multiple sources including near real-time satellite imagery, aerial photography and lightning strike detection. These services – referred to as FireWatch – were originally built for the use of emergency services professionals. In usability terms, FireWatch was stymied by its history as a service for technical users, in that its emphasis on providing a high level of technical data resulted in a lack of consistency and ease of use in the interface. The major aim of this research was to redesign a public access version (Figure 1) of FireWatch for the use of non-technical users in the wider community, using a trial regional community to fine-tune the service. The redesign aimed to present a more usable and intuitive interface for these non-technical users. The focus of the redesigned interface is on wider community use. The intention is to inform communities of actual and potential fire dangers in their community and assist them in making decisions of how to prepare and respond to these dangers. After several design iterations, which included direct input from users in rural communities, the redesigned interface was launched as an officially supported publicly-accessible web application known as MyFireWatch [1] in 2014. This research was undertaken as constructive design research, which "refers to design research in which construction – be it product, system, space, or media – takes centre place and becomes the key means in constructing knowledge. Typically, this 'thing' in the middle is a prototype" [2]. Part of undertaking constructive design research involves generalising from the specific in order to generate frameworks and guidelines for others who may be working in a similar realm [2].

Hence, a framework is presented here – in the form of a pattern language – that generalises from the MyFireWatch design process and results generated by this research so that those aiming to present hazard information to community-based users – including the development team of

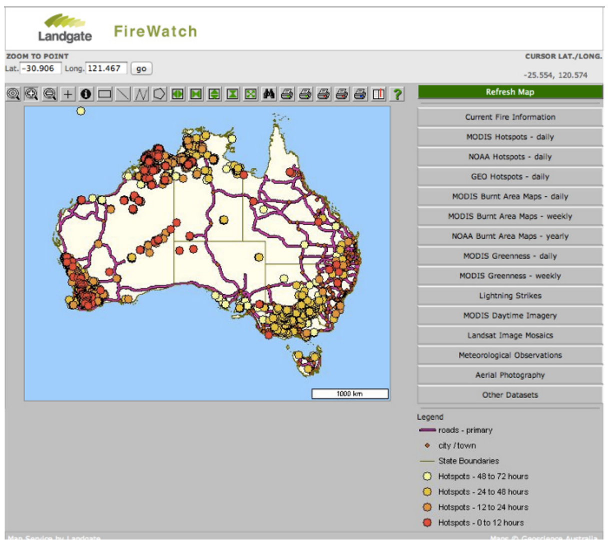


Figure 1: The original publicly-accessible version of the FireWatch application.

the industry partner Landgate – have a starting point for undertaking their own design work. These design patterns focus on improving both usability and utility of an interface and were formed as a result of multiple rounds of user input through various methods including semi-structured interviews, observations, testing of the interface (The final version is shown in Figure 2) and a usability questionnaire.

2 Pattern Language

Created by Alexander et al as a language for describing solutions to problems identified in architecture [3], pattern language found its way into software engineering and HCI in the 1990s [4, 5]. Interaction design has continued this practice [6]. Design patterns improve on style guides and standards as a way to express interaction design experience [5]. Patterns provide interaction designers with a means to a concrete example and a generalised solution while also offering a context in which to apply the solution [5]. A pattern language also has a hierarchy, which "leads the designer from patterns addressing large-scale design issues, to patterns about small design details" [5]. In interaction design research, design patterns serve the purpose of formalising design knowledge and documenting best practices [6]. Design patterns serve to reduce design time and effort on new projects, can improve the quality of design solutions, facilitate communication between designers and programmers and educate designers [6]. Borchers noted that Alexander's intention with pattern language was "to allow not architects, but the inhabitants (that is, the users) themselves to design their environments. This is strikingly similar to the ideas of user-centered and participatory design" [5]. For this reason, Borchers noted that design patterns acted as a universal language amongst members of interdisciplinary design teams [5].

2.1 Working with users of the MyFireWatch system

The pattern language explained here arose as a way of generalising outcomes from the final MyFireWatch design iteration, which was the result of two rounds of user testing, observations and interviews, plus a usability questionnaire where online users provided feedback on the final design iteration of the MyFireWatch system (Figure 1). In the two rounds of user input, users (n=17) were first asked to rate - using a card system [7] - the following features provided by the MyFireWatch system in terms of usefulness (Very useful, somewhat useful, somewhat non-useful, very non-useful):

- Aerial view of the terrain (satellite view)
- Previously burnt areas
- Current fire hotspots
- Greenness of vegetation
- Lightning strikes
- Location search
- Weather data [7].

Users were able to elaborate on their ratings and were also asked whether there were any additional features not provided that they thought would be useful. Only features that had an average rating of "very useful" or "somewhat useful" were included in the interface. Users then spent several minutes using and evaluating the interface before being asked a series of questions in a semi-structured interview regarding usability of the interface and whether the functionality provided met their needs [7, 8]. The input from users in these two rounds of user input directly informed the design of the MyFireWatch interface (Figure 2), including the choice of features included in the interface, the placement of these features and how these were presented [7, 8].

The final version of the MyFireWatch interface was then made publicly available [1]. Coinciding with this new publicly accessible version of MyFireWatch was the online launch of a usability questionnaire, based on the System Usability Scale (SUS) [9]. An interface that scores more than 68 out of 100 on the SUS is considered a usable interface [10]. The averaged results amongst responses (n=34) to the online usability questionnaire was 74 out of 100, meaning that it provided the majority of users with a usable interface which met their needs. 74% of respondents found the application easy to use. 83% of respondents said that it was quick to learn how to use the application. 62% of respondents said they would use the application frequently. Less than 1% of respondents found the application unnecessarily complex and that there was too much inconsistency in the design. These positive results verified that the design process undertaken in two rounds (user testing, including a card rating system, observations and a semi-structured interview [7, 8]) with users resulted in a usable interface that met the needs of the majority of community-based users.

2.2 Structure and use of the patterns

The pattern language described here consists of 17 individual design patterns to guide designers, researchers, application developers and GIS (geographical information system) experts working with map-based hazard information. As a way of generalising from the results generated through the two rounds of user input and the online questionnaire [7, 8], these patterns were created as a way to guide others working in a similar area. The patterns were also created to assist Landgate in the event that they design or redesign other similar map-based products that present hazard information to community-based users.

The patterns are grouped into three categories, based on the categories of the requirements used to guide the design iterations: functional requirements, data requirements and other requirements [6]. Definitions of each of these categories are included in the pattern language below. Grouping requirements into these three categories proved to be effective when establishing requirements at the beginning of each iteration of the redesign process that resulted in the MyFireWatch application [8]. They are therefore used here for categorising the design patterns. Following the requirements described in these design patterns is likely to provide a strong foundation for a map-based hazard information application that is both useful and usable for community-based users.

The patterns follow the same structure Borchers [5] described within the context of HCI and interaction design, with each pattern comprising a name, problem, context, solution, example, references (to other relevant patterns within the pattern language), and – where appropriate – a diagram of an example solution. The solutions provide a general way of addressing the identified problem, while examples provide a specific example of how the problem has been previously addressed. Examples also include references to user feedback acquired in the user testing and questionnaire described in the previous section. The example diagrams are taken from the final version of the MyFireWatch interface. These components

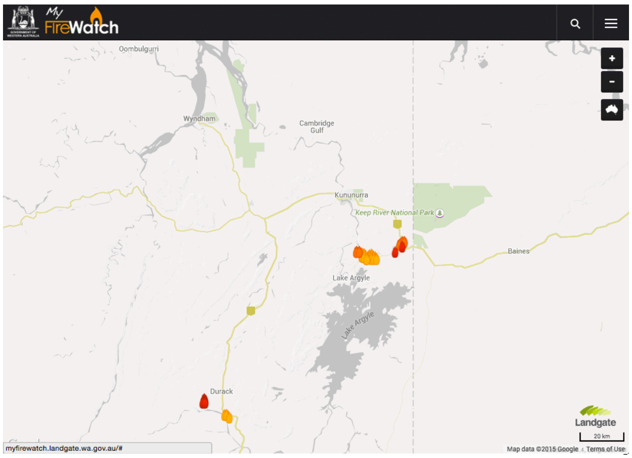


Figure 2: The mobile interface of the MyFireWatch application [1], which was launched in 2014.

are considered essential to design patterns [5]. For each design pattern presented in the pattern language described here, evidence is provided from the literature that guided the design process, as well as results that arose from the user input explained in the previous section. For ease of use and quick reference, the pattern language explained here only has two levels in the hierarchy (See Tables 1, 2 and 3). Level one patterns describe generalised, higher level guidelines while level two patterns refer to more specific features of the interface.

Table 1: Hierarchy of *functional* patterns

Pattern name	Hierarchy level
Simplicity	1
Consistency	1
All Devices	1
Geo-locate	2
Search	2
Zoom	2
Map	1

Table 2: Hierarchy of *data* patterns

Pattern name	Hierarchy level
Map navigation	1
Default information	2
Alerts	2
Satellite view	2
Other layers	2
Layer options	2

Table 3: Hierarchy of *other* patterns

Pattern name	Hierarchy level
Information source	2
Simple language	1
Minimal download time	1
Natural mappings	1

These patterns can serve as a starting point for establishing functional, data and other requirements prior to commencing an interface design for a hazard information system. However, as the individual patterns contain a significant level of detail and a specific example (and reference to a diagram where appropriate), they provide a solid foundation of how each requirement can be addressed, serving as a blueprint for how each requirement can be designed.

2.3 Functional patterns

Functional requirements are those which address “operations or actions that need to be performed on the objects of the system and which are typically translated into interface controls” [6]. These requirements include generalised principles for how to address the interface design, as well as the essential interface components.

Pattern name: SIMPLICITY

Context: A simple interface will be more usable. Simplicity is important, particularly when presenting hazard information to users.

Problem: Information related to hazards needs to reach the user quickly but also needs to be easy to understand [11].

Solution: Only provide features that are crucial to the application. Identify the core features. Consider whether or not to include sub-features. Any complex aspects need to be managed by a designer to make them easily understandable [12]. However, “when in doubt, remove” [13].

Examples: The original expert-user version of FireWatch provided several datasets for current fires. This included map layers labelled “Current Fire Information”, “MODIS Hotspots – daily”, “NOAA Hotspots – daily”, “GEO Hotspots – daily” and “NPP Hotspots – daily”. MyFireWatch contains only one set of current fire hotspots, labelled “Current fires”. This single set of hotspots met the needs of the community-based users who undertook user testing [7, 8].

References: The MAP feature should initially display DEFAULT INFORMATION only. OTHER LAYERS should be available, but these should only use minimal LAYER OPTIONS.

Pattern name: CONSISTENCY

Context: Elements that perform a similar function should be consistent in their actions and aesthetics.

Problem: Interface objects should be consistent with their behaviour. Objects with different behaviour should appear differently [14]. Users also prefer interfaces that they are familiar with [15].

Solution: Elements that perform the same type of function – such as the main site navigation and the map navigation – should have the same appearance and perform in the same way. They should use the same font, same font size and colour. If icons are used, they should be around the same size, and where appropriate, use the same or similar colours. Navigation should behave the same when clicked or touched. Web users in general seek familiarity and consistency in the interfaces they use [16], so follow conventions found in other map applications that users will be familiar with, such as Google Maps.

Examples: The MyFireWatch application's main navigation and map navigation's text and link behaviour are the same. The map navigation had different icons for each map layer, but these icons were approximately the same size, and similar layers (such as the four hotspot layers) were the same size. 16 of the 17 participants who provided input through user testing and interviews found the interface easy to understand.

References: Only use SIMPLE LANGUAGE in the interface. DEFAULT INFORMATION, OTHER LAYERS and LAYER OPTIONS should all be consistent in their appearance and function. Consider NATURAL MAPPINGS in the context of the visual aspects of the interface.

Diagrams: See Figure 4 and Figure 6.

Pattern name: ALL DEVICES
Context: The interface should work on mobile and tablet devices as well as desktop.

Problem: A modern interface needs to cater for several screen sizes, from a large monitor to the portrait orientation of a small smart phone. It should work on all common web browsers.

Solution: Use responsive design (Marcotte, 2011) to cater for all screen resolutions. All content should be flexible in its width. Wherever possible, use percentages rather than pixel values for an element's width. For example in CSS, set the content area's width to 100%. Text should be readable on all devices by using font sizes around 16 pixels and maintaining high contrast between the background and font colour.

Examples: In the MyFireWatch interface, the top area's width stretches across the entire width of the screen. This area adjusts according to the size of the screen being used, ensuring that it is easily accessible regardless of which device a user accesses the application with.

References: The MAP component will be the most prominent feature of the interface.

Pattern name: GEO-LOCATE
Context: The map should automatically detect the user's location.

Problem: The user needs to easily locate fires in or near their location.

Solution: Use geo-location functionality [17]. This feature is included in most modern browsers and smart phone operating systems.

Examples: MyFireWatch automatically detects the user's location using HTML 5's automatic geo-locate. This feature makes it easier for the user to orientate themselves [7].

References: SEARCH and ZOOM also allow the user to orientate themselves, but GEO-LOCATE automates this process.

Pattern name: SEARCH
Context: Users need to search for a location by address, a town name or postcode.

Problem: Users need to contextualise the information provided to a location of their interest. To do so, they want to search by information such as postcode, address or town name.

Solution: Allow users to enter information in an easy to understand format such as postcode, address or town name [7]. The search bar should be easy for the user to locate and should be displayed prominently above the map.

Examples: MyFireWatch allows users to enter location information in a variety of ways, including an address, a town name, postcode or latitude and longitude. The search bar is prominently displayed above the map feature. As several users overlooked the search feature in early iterations of the design, it was made wider and more prominent in the final design iteration.

References: GEO-LOCATE can automatically detect a user's location. ZOOM can allow a user to display the map at a resolution that is useful to their personal circumstances.

Diagram: Figure 3.

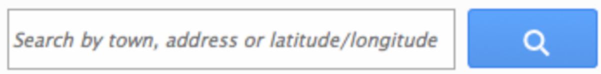


Figure 3: The search functionality provided by the MyFireWatch application. This feature was placed directly above the map and took up more than two thirds of the screen width. As some users overlooked this feature in early iterations of the design, it was made more prominent in the final design iteration.

Pattern name: ZOOM
Context: Users require controls to zoom in and out on the map.

Problem: Users need to scale the map feature to a resolution that is meaningful to their personal circumstances.

Solution: Add zoom controls in the top right corner of the map. These controls should be big enough to be easily accessed on a mobile or tablet device. A plus and minus sign have become de-facto standard ways of visualising this feature (e.g., [16, 17]).

Examples: MyFireWatch includes zoom controls in the top right of the map. These controls are displayed prominently and were big enough to be easily accessed by users who tested the application on mobile and tablet devices.

References: GEO-LOCATE and SEARCH can also allow the user to contextualise the information to a location of interest.
Diagram: The zoom functionality is visible in the top right corner of Figure 2.

Pattern name: MAP
Context: The map is the main focus of the application.
Problem: Spatial information related to the hazard should be displayed clearly and simply.

Solution: The map should be the largest component of the interface, using proportion to draw attention to it in relation to other elements [20]. The width of the map should take up most of the browser's width. The map itself should show town names, names of national parks and roads [7].

Examples: In the MyFireWatch interface, the map's width stretches to the right-hand side of the screen. On the desktop version, there is a left margin of 236 pixels to make room for the layer navigation. On the mobile version the map stretches to the left-hand side of the screen, meaning that the map component has a width of 100% of the screen.

References: MAP NAVIGATION is required to toggle the map layers – including DEFAULT INFORMATION and OPTIONAL LAYERS – on and off.

Diagram: The default map view is visible in Figure 2.

Pattern name: MAP NAVIGATION
Context: Controls are required to allow the user to toggle map layers on and off. The default hazard information is switched on by default.

Problem: Users require access to the information provided, and the ability to toggle the map layers on and off. Users also need to easily understand what the layers mean.

Solution: The navigation should allow users to toggle layers on and off. Where appropriate, the navigation icons can act as a legend for the map. Use both text and icons – multimodal communication – to portray the meaning of the layers. Simple terms should be used when labelling the layers. On the desktop version of the interface, the map navigation should be situated to the left of the map. This is the case with well-known map applications, such as Google Maps [18] and Bing Maps [19], as well as MyFireWatch (desktop version).

Examples: The MyFireWatch application provides navigation controls for every layer. The navigation is displayed to the left of the map feature on the desktop interface and is accessible via the dropdown menu on the mobile and tablet interface. Both text and icons are used to convey the meaning of the layers to the user. Only simple terms are used, such as "Current fires" and "Burnt areas". These terms were easily understood by users of MyFireWatch: no user who undertook user testing had problems understanding the terms used. In the case of the current fires, burnt areas and lightning activity, the navigation icons also act as a legend. For example, the fire hotspots navigation also acts as a legend – telling the users which icons refer to which timeframe.

References: The map navigation is used to control which map layers are displayed on the MAP. The navigation should only use SIMPLE LANGUAGE. Adding GEO-LOCATE makes it easy for the user to orientate themselves. Consider NATURAL MAPPINGS when creating icons for the map navigation.

2.4 Data patterns
Data requirements are those which discuss "objects and information that must be represented in the system" [6]. Here, the guidelines describe information provided by the interface that is related to hazards.

Pattern name: DEFAULT INFORMATION
Context: A hazard map should show only the hazard information by default.

Problem: Information related to hazards needs to be provided to the public. The information needs to be "timely and understandable to those at risk" [21].

Solution: The hazard information should be the only layer that appears on the map by default. This will make the information easy to understand for users at risk. Use of colour should be appropriate: for example, if there are common ways of representing a particular kind of information, that standard should be followed.

Examples: The MyFireWatch application only shows current bushfire information by default, on top of the map layer. Other information is accessed through the map navigation to the left of the map or by the dropdown menu on mobile and tablet devices. Layers that are currently shown on the map display a tick and a grey background. The colours of the icons use the same spectrum of colours used in the previous expert-user version of FireWatch (Figure 1) and Sentinel [22].

References: The MAP should be the most prominent feature of the interface. ALERTS and OTHER LAYERS can provide additional information to users. GEO-LOCATE, SEARCH and ZOOM can assist users in displaying the information at a resolution that is meaningful. Consider NATURAL MAPPINGS when creating icons for the default layers.

Diagram: Figure 4.

Figure 4: The default fire hotspot information provided by the MyFireWatch application. These are the only layers displayed when the interface initially loads. Only the essential hazard information should be displayed initially. Layers that are currently shown on the map display a tick and a grey background.

Pattern name: ALERTS

Context: Alert information should be added where available in addition to the default hazard information.

Problem: Users seeking more information about hazards will look to official alerts for further information.

Solution: Where possible, provide information from – or links to – official feeds of emergency services organisations. If the alerts are geo-tagged, they can be added to the map. Otherwise they will need to be displayed separately to the map feature [7].

Examples: The MyFireWatch application provides an Alerts page accessed by the main menu. The alerts are also linked from the popups accessed by clicking or touching the fire hotspots. Although few MyFireWatch users requested that alerts be provided, this feature was added due to a request from the service provider, Landgate. The information is provided by state and territory-based emergency services organisations with external links to those organisations. Where available, links to an organisation's Twitter page were also provided.

References: By default, the MAP should only provide DEFAULT INFORMATION. This default information can be supplemented by alerts and OTHER LAYERS.

Pattern name: SATELLITE VIEW

Context: Provide real imagery of the land by providing users with a satellite or aerial view of the terrain.

Problem: Users require real imagery of the land to orientate themselves to key features in the landscape at closer zoom levels [8].

Solution: Provide an aerial or satellite view that provides real imagery of the terrain.

Examples: In the MyFireWatch application, a satellite view is available under the "MAP OPTIONS" heading in the map navigation. MyFireWatch uses the satellite view from Google Maps. Participants who took part in user testing were more easily able to locate key features in the landscape when this layer was visible at closer zoom levels (i.e., larger scales) [8].

References: The satellite view should be one of a few OTHER LAYERS provided to users.

Diagram: Figure 5.

Figure 5: The satellite view provided by the MyFireWatch application. The application uses satellite imagery from Google Maps. Users require this realistic view of the terrain in order to orientate themselves to key features in the landscape.

Pattern name: OTHER LAYERS

Context: Provide some additional layers to supplement the default hazard information. These layers should not be visible by default.

Problem: Additional layers should be provided to users to supplement the default hazard information. This additional information can assist users in decision-making related to the hazards in their vicinity.

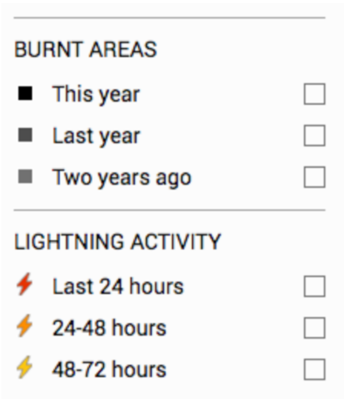
Solution: Provide additional information that is related to the hazard. This should include a satellite or aerial view of the terrain. Care should be taken to only provide information that is useful for non-expert users [7]. Relevant supplementary information may include historical data and meteorological information.

Examples: MyFireWatch provided users with five other types of information in addition to the fire hotspots: a satellite view, weather, greenness of vegetation, burnt areas and lightning activity. The inclusion and positioning of these layers was determined by feedback acquired from the card system used during user testing [7, 8].

References: Only provide up to three LAYER OPTIONS to users. Amongst these other layers should be a SATELLITE VIEW. Remember to consider NATURAL MAPPINGS when using icons.

Diagram: Figure 6.

Figure 6: The other layers provided by the MyFireWatch application. Care should be taken to ensure that these layers only provide information that is considered essential to a community-based, nontechnical audience.



Pattern name: LAYER OPTIONS
Context: Additional information on the map interface should only provide up to three options.
Problem: Information in addition to the default hazard information needs to be provided to users, to assist in decision-making. However, care needs to be taken to not overburden the user with too much information.

Solution: Provide up to three options for each type of additional information. This amount of information should meet the needs for the majority of community-based users [7].

Examples: MyFireWatch provides three map options to users: a satellite view, weather and greenness of vegetation. There are three years of burnt areas and three days of lightning activity. These layers met the needs of the majority of community-based users who undertook user testing [7, 8].

References: OTHER LAYERS should be provided, in addition to the DEFAULT INFORMATION.

Diagrams: See the diagram provided in the OTHER LAYERS pattern (Figure 6).

2.5 Other patterns
According to Cooper et al, other requirements can include things such as business, brand or technical requirements [6]. Here, they describe technical requirements, how to present technical information to non-technical users and also address issues such as credibility and use of icons.

Pattern name: INFORMATION SOURCE
Context: Information about the source of the hazard data should be available to users.
Problem: Users need to know the source of the hazard information being provided.

Solution: Information about where the data comes from should be provided. The information provided should be timely and relevant to the user. The navigation should also be easy to use. These aspects will add to the credibility and trustworthiness of the application [23]. If necessary, provide disclaimers if the data comes form external providers. The information source should be a known organisation and the source of the information should be made known to the user [23].

Examples: In the MyFireWatch application, Landgate is clearly the organisation responsible, as their logo appears on every page. Knowing that Landgate – a known state authority in WA – owns the application adds to its credibility and authority [23]. Participants who undertook user testing did not doubt the source of information. There is also information about the source of the data – and its limitations – on the Terms and Conditions page, the About page and on the main landing page of FireWatch.

References: The source of the information should be described in SIMPLE LANGUAGE. MAP NAVIGATION should be easy to use.

Pattern name: SIMPLE LANGUAGE
Context: The terms used in the interface should be easy to understand for a non-technical audience.
Problem: The interface needs to be easily understood by a non-technical audience. Complicated terms, such as industry-specific information, can confuse a non-technical audience.

Solution: Avoid jargon – it is likely that community-based users will not be familiar with many of the terms used by professionals. Use only simple language. The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-based terminology [15].

Examples: In the redesign of the expert-user version of FireWatch (Figure 1), which resulted in the community-user focused MyFireWatch interface (Figure 2), all jargon was removed. This included terms such as references to satellites (e.g., NOAA, MODIS, etc.) as these terms were unlikely to be familiar to community-based users.

References: Features of the interface, such as SEARCH and MAP NAVIGATION should use simple language.

Pattern name: MINIMAL DOWNLOAD TIME
Context: The application needs to be quick to load [16].

Problem: Many users will be accessing the application by a mobile or tablet device, and therefore may be reliant on a slower connection.

Solution: Only provide information that is essential to community-based, non-technical users. By default, only provide the minimum hazard information required when the map interface loads. Since users on mobile and tablet devices may have limited internet access, restrict the number of layers that they can access initially. Note that the application's performance will be affected by the capacity of the server it is on, which may be beyond the control of those working on the application.

Examples: In MyFireWatch, the fire hotspots are the only map layers displayed by default. Additional layers only load when accessed via the map navigation. On the mobile and tablet interface, only one day of lightning activity and only one year of burnt area data are available.

References: The MAP feature should initially display the DEFAULT INFORMATION only. OTHER LAYERS should be restricted to those that are considered essential information for community-based users.

Pattern name: NATURAL MAPPINGS
Context: It should be obvious to users what effect the controls have on the system.

Problem: A design needs to be intuitive, ensuring that the spatial relationship between a system and its controls is as direct as it can be [24].

Solution: The icons used should represent their function obviously. This obvious representation reduces the cognitive load on the user [24]. The choice of icons should reflect the kind of information being provided and the type of actions being performed. A common example of this is using a "plus" symbol for zooming in on the map and a "minus" symbol for zooming out.

Examples: In the MyFireWatch application, the current hotspot map layers use flame icons to indicate the location of current fires. The choice of icons used for the map layer information (and the map navigation icons) relates directly to the type of information that the map layer provides and were understood by the majority of users who undertook user testing [7, 8]. The zoom controls for the map use plus and minus symbols for zooming in and out – a common way of providing this functionality (e.g., [18]).

References: When creating the MAP NAVIGATION, SEARCH and ZOOM features, consider natural mappings.

Diagrams: Consider the diagram under OTHER LAYERS (Figure 6). The icons used should relate directly to the kind of information provided by the map layers.

3. Further use and development of the pattern language

Currently, a project is being undertaken in Japan that aims to make disaster information more accessible to Japanese communities, that is, members of the public outside of emergency services personnel. The pattern language presented here served as a starting point for the prototyping of an iPhone application which shows active volcano warnings in near real-time [25]. In addition to serving as a set of requirements for the prototype, the pattern language was used to guide the development of each feature in this application such as searching, zooming and panning the map, and other navigational and data elements. This application serves as an example of how the pattern language presented here can be applied in a similar context. This iPhone application is currently undergoing user testing which will inform a future version of the pattern language described here. Early results (n=6) from this user testing suggest that the volcano warning iPhone application is not too complex, and easy to understand and use. Although user evaluation of this new application is ongoing, this early positive result suggests that referencing the pattern language described here will assist in creating an effective interface when building a similar system.

A copy of the pattern language has also been provided to the development team at Landgate as guidelines to refer to when developing future map-based services for community-based users.

Re-contextualising and evaluating these patterns through further user input will lead to further refinements of them.

4. Discussion and future work

The pattern language described here is considered a small step towards improving the communicative and informative aspects of internet-based hazard information available to communities vulnerable to such hazards. Others working in similar domains may use the pattern language as a starting point in their design process, which will then lead to further refinement of the patterns. As suggested by the user engagement described in the second section, community-based users looking to gain a more meaningful understanding of natural hazards may have a more satisfying user experience as a result.

Clearly the effectiveness of services such as MyFireWatch is highly dependent on the robustness and timeliness of the sensing technologies that detect hazards such as bushfires. As these technologies improve, so too will the usefulness of these services. The work described here means that as demand for and interest in these services grows, the interfaces will not be a barrier for users seeking such information.

5. Conclusion

This pattern language for hazard information systems deliberately avoids the specificity of software versions and industry jargon as these are constantly changing aspects of mapping software and various interaction contexts. The pattern language presented here rather revolves around user cognition, evolving out of results from two rounds of user input (through user testing, observations and interviews) and a user questionnaire. The desire to make an interface more intuitive for non-expert users overlaps completely with the need to provide a design process that does not have to change with every version of mapping software.

As noted by Borchers, communication amongst interdisciplinary design teams can be problematic for those who wish to communicate interaction design concepts and guidelines. Pattern language removes this communication barrier due to its universality. The example given here of a pattern language, and future examples that will refer to it and refine it, only strengthens Borchers' argument that pattern language ought to be a lingua franca for interaction design.

6. Acknowledgments

The first and second authors are grateful for funding for the MyFireWatch project from both the Australian Research Council (ARC) and Landgate, and wish to thank their ARC research colleagues at Edith Cowan University and Landgate. The Mapping Hazards in Japan research is funded by the Japan Society for the Promotion of Science.

References

[1] Landgate. MyFireWatch - bushfire map information Australia http://myfirewatch.landgate.wa.gov.au/, 2015.

[2] Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J. and Wensveen, S. *Design Research Through Practice: From the Lab, Field, and Showroom*. Morgan Kaufmann Publishers Inc., 2012.

[3] Alexander, C., Ishikawa, S., and Silverstein, M. *A Pattern Language: Towns, Buildings, Construction*. OUP USA, 1977.

[4] Gamma, E., Helm, R., Johnson, R. and Vlissides, J. *Design Patterns: Elements of Reusable Object-Oriented Software*. Pearson Education, 1994.

[5] Borchers, J. A pattern approach to interaction design. *In Proc. of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*, pages 369-378. ACM, 2000.

[6] Cooper, A., Reimann, R., & Cronin, D (2014). About Face 3: The Essentials of Interaction Design: Wiley.

[7] Haimes, P. *Designing for communities in bushfire-prone situations: Redesigning the FireWatch website interface*. (PhD), Edith Cowan University, Australia.

[8] Haimes, P., Brady, D., Clarkson, B., & Medley, S. (2013). *Engaging with communities as a design process: redesigning the FireWatch interface.* Paper presented at the Australian & New Zealand Disaster and Emergency Management Conference, Brisbane.

[9] Brooke, J. (1986). SUS – A quick and dirty usability scale. http://cui.unige.ch/isi/icle-wiki/_media/ipm:test-suschapt.pdf

[10] U.S. Department of Health & Human Services. (2012). Improving the User Experience. Retrieved from http://www.usability.gov/how-to-and-tools/methods

[11] Wu, P.F. Motivation for adopting emergency response technology in community settings. *In Proc. of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction* - Volume 2, pages 259–260. British Computer Society, 2008.

[12] Norman, D. *The way I see it: Simplicity is not the answer. interactions*, 15(5):45–46, 2008.

[13] Maeda, J. *The laws of simplicity*. MIT Press, Cambridge, MA, 2006.

[14] Tognazzini, B. First principles of interaction design http://www.asktog.com/basics/firstPrinciples.html, 2014.

[15] Nielsen, J. Ten usability heuristics http://www.useit.com/papers/heuristic/heuristic_list.html, 2005.

[16] Nielsen, J. *Designing web usability*. New Riders, Indianapolis, 2000.

[17] Lawson, B. and Sharp, R. *Introducing HTML5*. Pearson Education, 2011.

[18] Google. About Google Maps. http://support.google.com/maps/bin/answer.py?hl=en&answer=7060, 2015.

[19] Microsoft Corporation. Bing Maps. https://www.bing.com/maps/, 2015.

[20] Evans, P. and Thomas, M. *Exploring the Elements of Design*. Thomson/Delmar Learning, Clifton Park, 2007.

[21] United Nations International Strategy for Disaster Reduction [UNISDR]. Hyogo framework for action 2005-2015: Building the resilience of nations and communities to disasters. http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf, 2005.

[22] Geosciences Australia. Earth observation and satellite imagery - Sentinel. http://sentinel.ga.gov.au, 2015.

[23] Fogg, B. *Persuasive technology: using computers to change what we think and do*. Morgan Kaufmann Publishers, San Francisco, 2003.

[24] Norman, D. *The design of everyday things*. Basic Books, New York, 2002.

[25] Haimes, P. iTunes Preview: Katsukazan. https://itunes.apple.com/jp/app/katsukazan/id1084989877.

Received March 17, 2016; Accepted April 2, 2016

International Journal of Asia Digital Art & Design

Production of Learning Materials for Special Education Support Adjustable for Individual Capabilities Using a Tablet Device

Kume Hayato
Kyushu University
Hayato.kume7@gmail

Kim DaeWoong
Kyushu University
dwkim@design.kyushu-u.ac.jp

Ishii Tatsuro
Kyushu University
tatsuro@design.kyushu-u.ac.jp

Abstract

In recent years, as a result of improvements in the awareness of people and development of medical science, the number of children diagnosed with developmental disabilities tends to increase. Special education has been reviewed in the Developmental Disabilities Assistance Act of 2004, which has been since being adopted by the education field.

Special education must be devised for teaching materials and learning content to suit the student. For this reason, making a high-quality learning on an ongoing basis is difficult.

Therefore, the use of a teaching device that is suitable for this specific kind of education is effective. In recent years, the introduction of tablet computers to the education field has been increasing. Tablets can be easily operated, and it is possible to include content with audio and video features, which is beneficial for special education. Many studies have been previously made, however these are still only case introductions or reports on usage of tablet devices in the classroom. In our investigation, no practical case that the included actual teaching materials was found.

In this study, we produce learning materials for the iPad, which is easily available for students receiving special education, and can support them continuously in self-learning activities. We propose to find a new direction for special education materials in the future.

Keywords: Support for special education, Tablet device, Learning materials

1 Background

The number of students diagnosed with developmental disabilities has been is increasing. According to a survey of the Ministry of Education of Japan, by the 1st of May 2014 0.34 million students are receiving some kind of special education; from a total of 10.19 million of Japanese students belonging to compulsory education, 3.33% are in special education programs. (Figure1)

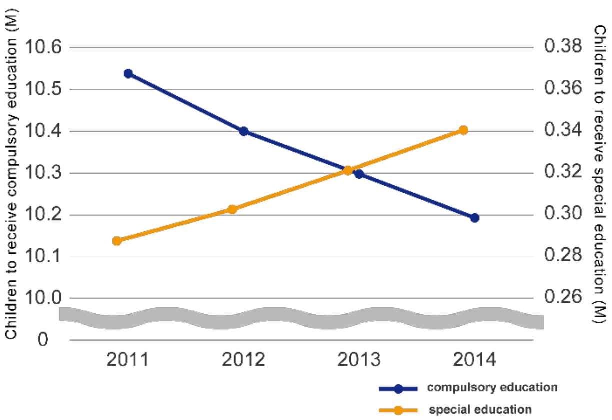


Figure 1 Transition of the number of children to receive compulsory education and special education

The “Developmental Disabilities Assistance Act” was created as a response to this trend, which is the leading association for development support of national and local governments on special education in schools. Educators have now given the task of dealing with this increase in the number of special education students and they have been reviewing learning support methods. Special support education is performed in a one-to-one method between teachers and students because it is necessary to examine the learning contents that suit the student’s degree of disability and to plan accordingly. The current number of teachers is insufficient, this is because special support classes are organized for maximum six students, and one teacher for each class is assigned. Compared to the regular class of one teacher for about forty students, the special education requires more human resources.

In order to solve this problem, studies about the introduction of digital teaching materials that effectively support special education have been performed in Japan. Specially, there has been a growing expectative on the usefulness of tablet devices. Some of is this reasons are that tablets can be intuitively operated through a touch panel, visual and audio stimuli for learning can be incorporated, also they are portable and easy for children to handle at any time. However, the actual number of schools that uses tablet devices is small because it takes a lot of time for the teachers to search for content suitable for the students.

Taking the above points in consideration, we visited special support classes in two junior high schools. Both of the schools take advantage of digital teaching materials through computers and large-screen televisions; children have been mastering the equipment with ease. When we asked the instructor about the use of digital teaching materials, she responded: “Teaching materials that include video and music can be used in classes for maintaining the motivation of children that have difficulty visualizing the learning contents”.

In special support classes, children have differences in their individual academic performances. Therefore, it is difficult to proceed with the development of teaching materials in the same way as regular classrooms.

Since the digital teaching materials are still in an introduction phase in order to be used in regular classrooms, studies around digital teaching materials that respond to the minority of special needs education has not been enough.

2 Objective

This study aims to develop a learning application for tablet devices aimed at special education. The difficulty settings of this application are designed in a way that can be changed in order to balance the difficulty of learning contents corresponding to the students’ individual capabilities. In addition, a system that implements game elements in order to enable students to learn while having fun will be developed. In order to make reviews of contents already learned by the students, questions using the drill method were prepared for the units of national language and mathematics.

3 Related research

As a related example, "Magical pencil box project" was investigated. This is a research about tablets applied for special education; it was initiated by the Research Center for Advanced Science and Technology by the University of Tokyo in collaboration with SOFTBANK MOBILE Corp. In this project, a manual that summarizes important points for tablets utilization in education was created. However this study is limited to introducing the usage of tablets and explaining how to implement them in school classes.
(“Magical pencil box project”: http://maho-prj.org/”)

4 Previous Research

In a previous research, we developed an application for tablet devices aimed at special education that included activities for basic mathematics.

In this application, a variety of characters appeared, and the player recruited them as companions by giving the correct answers to mathematics problems. Thanks to this, the students were able to learn with enthusiasm. Furthermore, there was a set of movable blocks that helped the users to make calculations. (Figure2)

Figure 2 Content flow of the previous research

A verification experiment took place in a special support education class, and the results obtained demonstrated that the students could study longer than usual because they showed an interest in the characters.

We concluded the following:

1. Incorporating the game into the teaching material was effective for reducing stress and adverse feelings on learning.
2. It is possible to increase the sense of accomplishment by actively showing a positive response when the correct answer is given.
3. It is possible to offer the liberty of selecting different learning methods for children that influence their motivation for learning.

On the other hand, we got feedback from teachers that suspected that some students felt frustrated because their range of learning was small.

Also, from the observation on the students’ behavior, we concluded that a user interface that responds to double tap and "barrage" tapping gestures should be implemented.

We took the findings of this previous research in consideration in order to make improvements. (Figure 3)

Figure 3 Photos of the on-site experiment

5 Contents Design

5.1 Overview of content

In this research, we developed an application with teaching materials for tablet devices aimed at supporting special education. It was designed based on the units of Elementary School as a learning support tool with the purpose of transmitting a deeper understanding of topics that the students are currently learning.

The content consists of two sections, national language (kanji) and mathematics. The kanji teaching material incorporate the understanding of radicals through images. Mathematics included basic sum, subtraction, multiplication, along with the knowledge for calculating time and money.

Furthermore, an equipment system was designed in order to offer the players the possibility of changing the difficulty and adapt the application to their own skill level. Also a record page was implemented in order to show the player's achievements.

5.2 Content flow

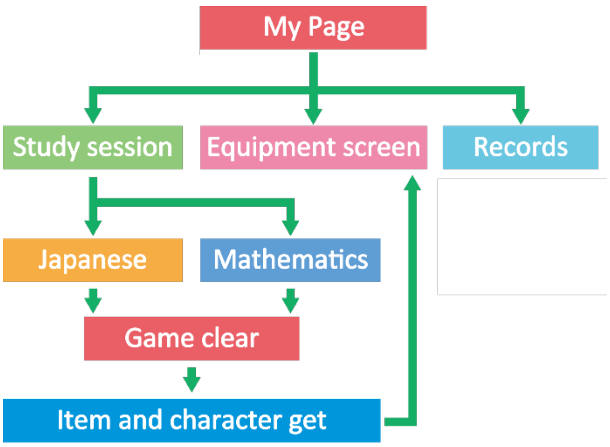


Figure 4 Content flow of this application

In Figure4 a diagram showing the flow of the developed application is presented. At the beginning of the application, a boy or girl main character can be selected. Then, the selected character appears along with the home screen, and from there, it is possible to navigate to each page. The player can select to start a study session, change their avatar's accessories in the equipment screen, or view their records. (Figure5)

Figure 5 Flow to the home screen

The learning contents include the units of national language and mathematics. There are different characters corresponding to each of the learning units. By achieving goals in the respective units, they receive medals as rewards.

The users can change the equipment of their avatar in the equipment screen in order to adjust the difficulty of the teaching materials.

In the records screen, the player can check their achievements like a picture book.

5.3 Specification of content

- National language unit (Figure6)

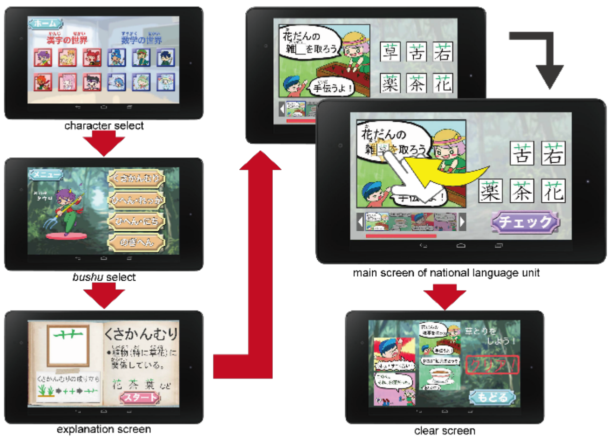


Figure 6 Flow of the national language unit

The national language unit deals with the Japanese kanji, taking particular note of the *bushu* (radicals) in order to learn the kanji through associating the meanings of the *bushu*. When a *bushu* is selected, an explanation screen is displayed. After reading the commentary, the start button is pressed and an activity of filling the blanks on a four-frame comic begins. The player has to fit the correct kanji according to the comic's story. If the correct answer is given, the kanji fits into the blank and a success response is displayed. When all the blanks are filled, the story is completed and the user can read the four-panel comic. This way, it is possible to check again the kanji that has been studied.

According to interviews with the teachers from the special education classes, learning each bushu systematically in a coherent and comprehensive way helps with the understanding of the more advanced contents. Furthermore, it is known that by working with stories that show the kanji’s usage in context, it becomes easier to visualize the meaning of the kanji, therefore short stories presented as four panel comics were employed.

- Mathematics unit (Figure7)

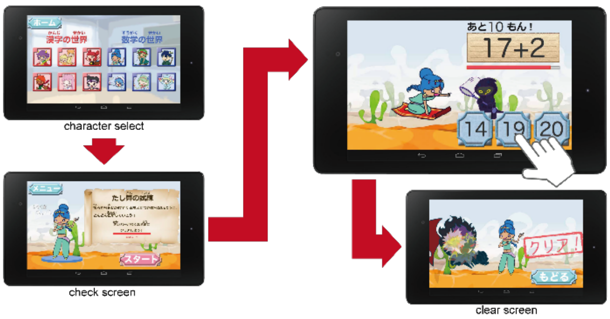


Figure 7 Flow of Mathematics unit

The mathematics unit includes basic arithmetic operations related to calculation of money and ways of reading time necessary for everyday life.

When a learning stage is selected, an escaping game where a character has to run away from a monster begins. In order to prevent the monster from getting close, the user has to select the correct answer from three choices within the time limit.

If the answer is correct the character proceeds to the next question. When the answer is wrong, the character remains inoperable for a certain amount of time, meanwhile the monster approaches from behind. If the monster reaches the character, the game over screen is shown.

When the player answers correctly all of the problems within the time limit, the stage is cleared and an animation showing the monster exploding.

Solving several short calculation problems in a limited time serves for getting used to numbers and improving the precision when making calculations. The objective of this material is that instead of problems that require a long thinking time, like the ones found in textbooks, several calculation problems thought as minimum requirement for practical life are implemented in order to cultivate the students’ autonomy.

- Change of equipment (Figure8)

The students can change the equipment of their characters in order to make the problems easier or harder. For example by equipping a certain item, the number of problems found in the stages is reduced, or the time limit is extended. This is a method for provisioning educational material with the possibility of changing the difficulty level according to the each student's needs. Furthermore, changing the difficulty through equipping different costume parts results in an enjoyable action. The changed equipment is shown in the home screen with the character wearing the current selected pieces.

Regarding the time limit, the answer speed for each problem varies depending on the student. The time can be increased for those that need more time for thinking, also the number of questions can be reduced for students who can’t focus for long

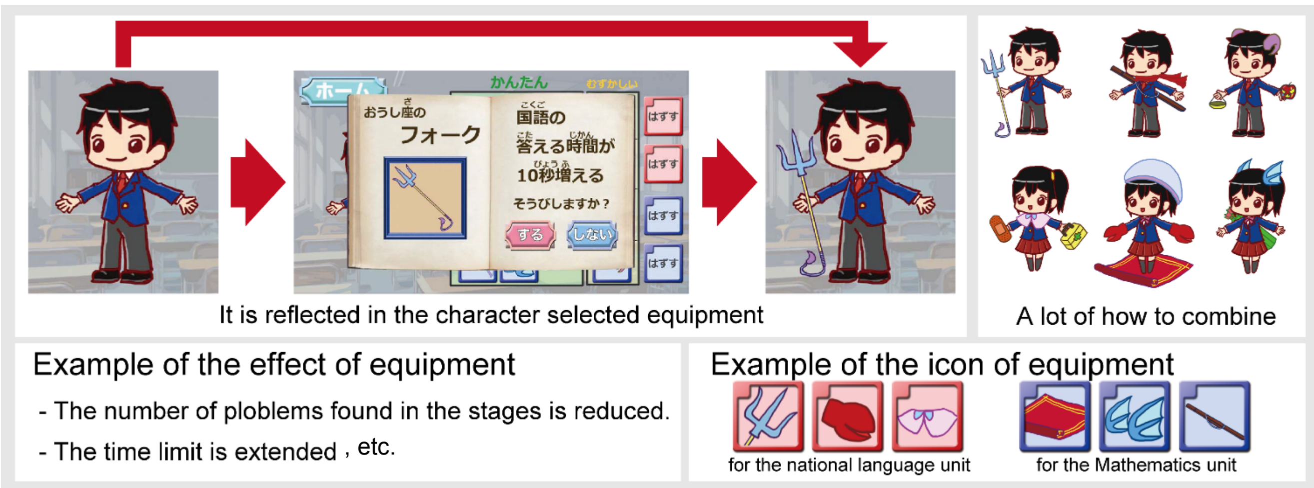


Figure 8 Overview of change of the equipment

periods of time. This is implemented in order to help them find the best way to easily solve the problems. Furthermore, the system allows increasing the materials' difficulty in order to further improve the learning level. The way in which the desire to be challenged is stimulated is explained in the Records screen section below.

- Records screen (Figure9)

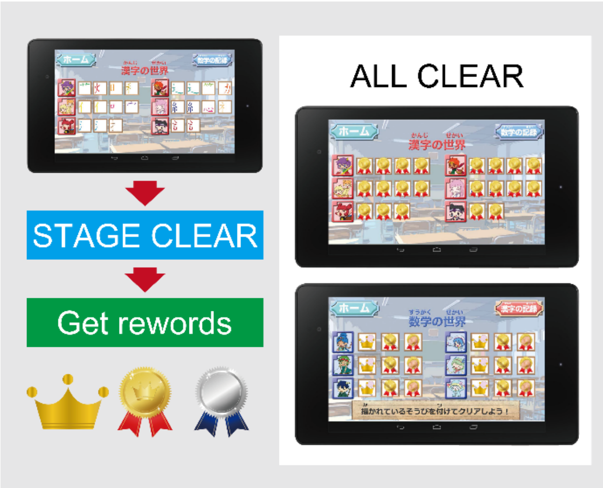


Figure 9 Records screen and complete screen

The cleared stages corresponding for reach subject can be viewed in the records screen. In the case of clearing a level with regular difficulty, a silver medal is displayed as reward. However, if cleared with one or more of the equipment pieces that increase the difficulty level, gold medals can be achieved. Furthermore, if the level is cleared using all of the equipment that increases the difficulty level, it is possible to win a crown. This reward system corresponding to the degree of difficulty is aimed at improving the learning motivation of the students.

When the difficulty level is increased, better prizes can be achieved. This was implemented as it serves for encouraging the students' desire to be challenged.

6 Verification experiment

A verification experiment was conducted in order to test the digital teaching materials produced in this research, and determine their effectiveness for special education support.

The tablets containing the application were lent to special education's classes for a few days. This was made in order to create an environment in which children could freely use the material. A total of 21 students participated in the experiment.

The evaluation was carried out in two ways: interviews with the classes' supervisors and individual surveys for the children. (Figure10)

The contents of the questionnaire were: whether the teaching materials were fun, the difficulty level, whether it was easy to use, Whether the equipment and achievement systems were significant, and finally an open question on their general thoughts about the teaching materials.

Figure 10 Photo of verification experiment

According to the survey's results, most of the students showed positive results towards both of the learning units. However, a portion of the students that regularly have aversion towards studying, felt that the application was boring. We felt that further investigation should be pursued in order to create contents that this kind of children can also enjoy.

The answers to the questions regarding to the teaching material difficulty showed that almost all of the tested students considered the contents easy. This was because the learning contents included in the application were meant to be a review of things already learned in the elementary school curriculum. Because of this, we consider that content that can expand the current learning material should be implemented in order to present a further challenge for the students.

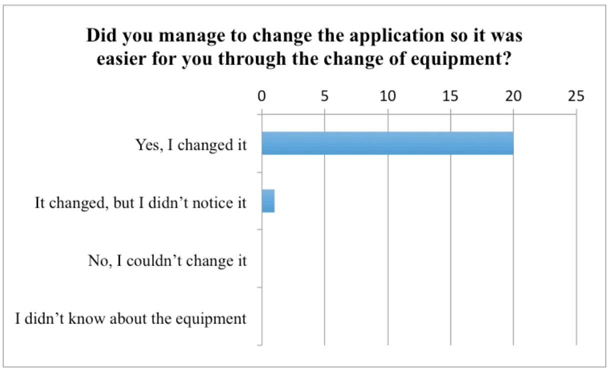


Figure 11 The result of question about the effectiveness of the equipment function

The equipment system made for changing the difficulty of the stages showed to be enjoyable for most of the children. This system resulted useful for responding to each student's needs, along with interesting them with the parts visuals. On the other hand, it resulted boring for the students to have all the equipment from the beginning, and that they had little variation among them. We concluded that new equipment should be obtained through the progression of the game, along with making improvements on the visual design.

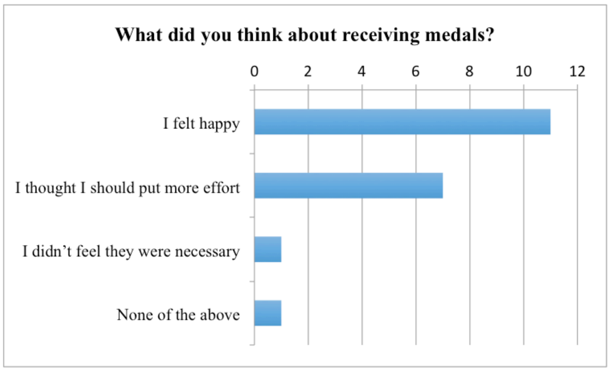


Figure 12 The result of question about medals

The achievements in the records screen proved useful since the students showed interest in obtaining them and tried increasing the difficulty level. The students felt motivated to tried harder challenges because they saw their effort represented in a visual way.

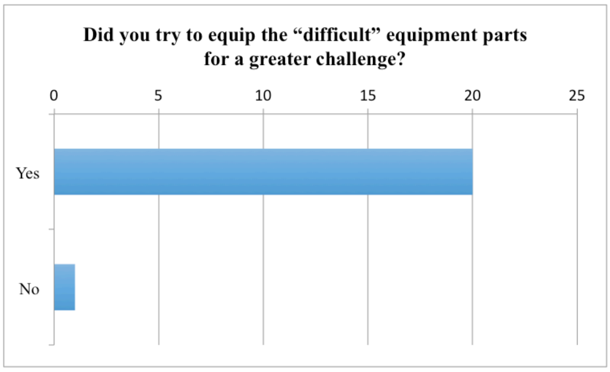


Figure 13 The result of question about "difficult" equipment

However some students were uninterested in the rewards because they were not real physical things.
In addition, all of the students except for one person responded positively when asked if they would like to use teaching materials similar to the one developed in this study. From the above we concluded that the application resulted useful and it represent a step forward for developing teaching materials for tablets in the future.

Below, the overall impressions as described by the students on the last question of the survey are summarized.

Positive content
- "I could check some kanji that I didn't know."
- "I think anyone can enjoy it"
- "I tried to get the gold medals because it was frustrating to see the game over screen"
- "I was very happy when I was able to complete all of the gold medals"

Demands on specific content
- "It would be good to have dialogue and stories for each character"
- "I would like to see the characters in the mathematics games have better movement"
- "I want to get equipment by clearing stages"
- "I would like to try more difficult problems"
- "I want to have a way of reviewing the answers I had wrong"
- "I would like to have other school subjects, such as science or social studies"

From the demands on specific content from the students we reached the following conclusions.

Since the students had a positive reaction towards the characters, developing them further through dialogues and story elements could enhance their effect. There was also a comment about improving the movement of the characters in the game, meaning that animations should be implemented. Also, for each stage, besides getting medals and other types of equipment, ways of implementing harder challenges for the students should be thought in order to sustain their motivation.

Additionally, time to think on the answered question should be considered in future teaching materials. Rather than starting over from the beginning when a problem is answered wrong, there should be system that focus on learning how to solve the wrong problem. We also learned that students would like to see these kinds of teaching materials for other subjects such as science and social studies.

After the verification experiment, interviews of the teachers took place. The opinions and impressions of the educators are summarized below.

- In regards to the kanji stages, using the *bushu* for explanation was a good thing, since the understanding of the radicals has a great influence on remembering the kanji.

- We would like to see other teaching materials that not only show how to read the kanji, but also focus on writing them.

- About the mathematics stages, teaching about the calculation of money through games resulted in an enjoyable experience for the students. We would like to see questions that incorporated real life examples, for example counting change when buying something in a shopping mall.

- Regarding the equipment function, the students seemed to understand and use the system with ease.

- The records screen was useful for visualizing the student's own achievements, was a good method.

- We would also like to see in the future these kinds of materials for other subjects such as science and social science, but also for sub-subjects such as art and home economics.

- In addition, teaching materials on tablets could be aimed no only at children with learning disabilities, but also for children.

We received a positive response from the educators in charge of the special needs classes. Furthermore, they showed high expectations for future digital teaching materials, not only for topics included in the curriculum of the school, but also in various activities related to the special education needs classes, for example keeping a diary or administrating the students' time schedule.

We also observed the student's way of appropriating the application and noticed that they showed a competitive behavior. They talked among themselves in order to start the same stage at the same time and competed to clear it first. Because of this, a system that encourages this competitive behavior could be implemented in order to further enhance their motivation to get better. (Figure14)

Figure 14 The competitive behavior

7 Conclusion

In this study we proposed a different approach for making teaching materials directed towards special education. This consisted in making an application on tablet devices that included video games in order to motivate the students to learn by themselves and improve their will to learn. In addition, a system that could let the students change the difficulty of the educational contents in order to address their respective academic level was thought.

The result of the verification experiment showed that with the video games embedded teaching materials it was possible to improve the motivation of the students in learning, and also reducing adverse feelings towards studying. Furthermore, offering rewards in the form of digital achievements, along with the optional difficulty selection, resulted in the will of taking higher challenges.

On the other hand, the rewards contents, the reward acquisition timing, and the conditions for clearing a stage needs to be reviewed in order to address the issue of students that found the contents too easy and felt boredom.

Teaching materials for special education support should take in consideration ways of corresponding the individual needs of students according to their each educational level. It is also important to transmit the contents that should be learned in a manner of objectives easily recognized, such as the stages on a game user interface. In addition, it is important to include problems that deal with real life situations in order to facilitate the understanding of certain contents. This investigation expects to serve as basis for future research regarding development on special education's resources.

References

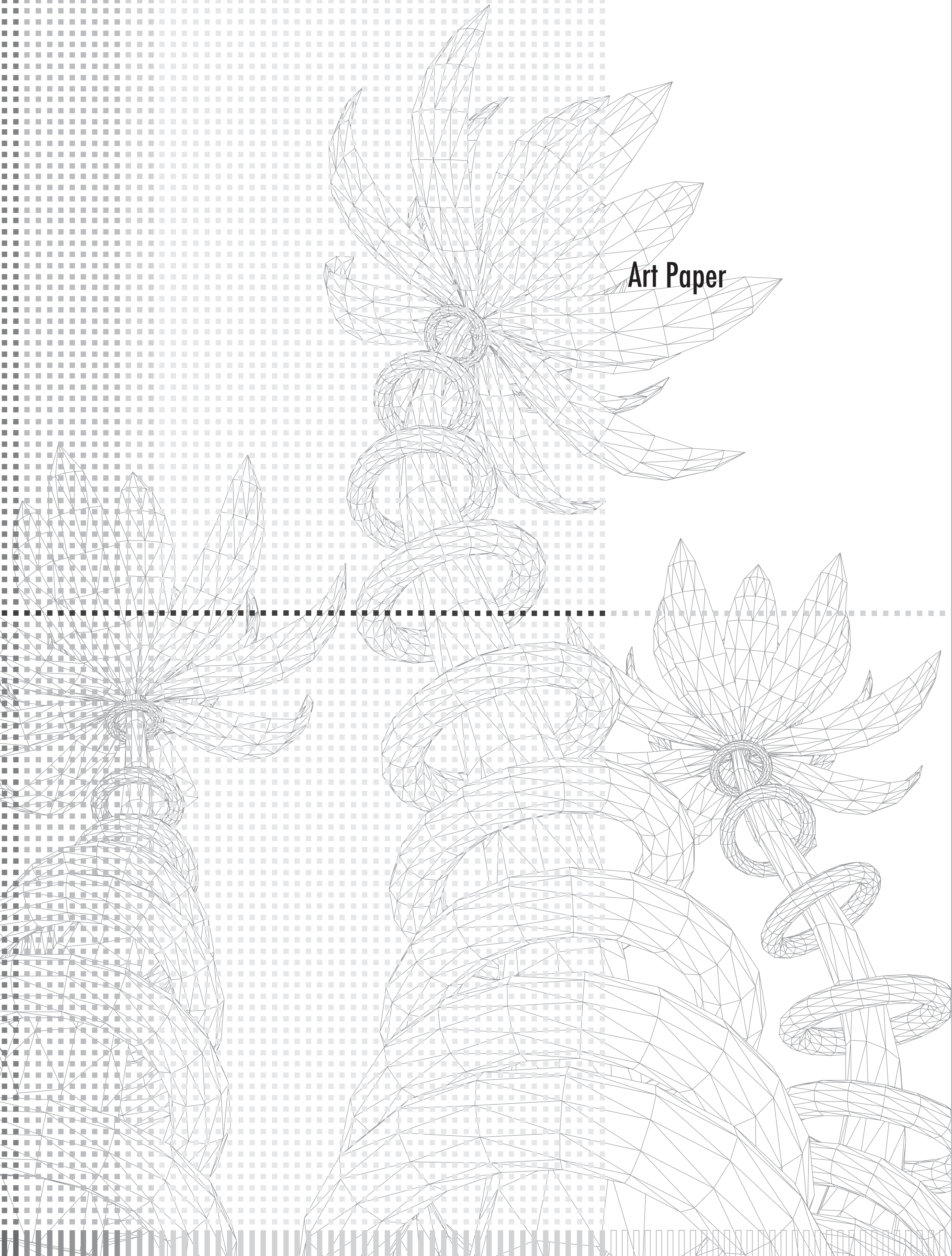
[1] Ministry of Education, Culture, Sports, Science and Technology, Conceptual view of the subject of special needs education, Web 16 Mar.2016.
<http://www.mext.go.jp/a_menu/shotou/tokubetu/main.htm>

[2] "Magical pencil box project", Web 16 Mar.2016.
< http://maho-prj.org/>

[3] Shin, K., *Chitekisyougai・Jiheisyou・Gakushusyougai No Kodomo He No Gakushu Shien [Learning support for children with intellectual disability, autism and learning disability.]*, Meijitosho, 2010.

[4] Ohminami, H., Kurashi Ni Yakudatsu Sugaku [Mathematics to help you live.], Touyoukansyuppansya, 2013.

Art Paper



International Journal of Asia Digital Art & Design

Received March 17, 2016; Accepted April 2, 2016

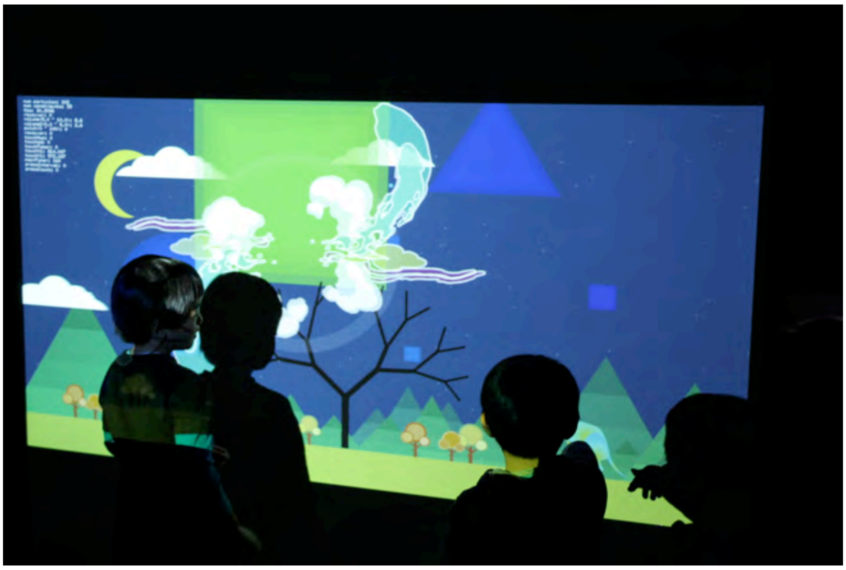
Toshiya, Nishimura
Kyushu University
1ds10182r@gmail.com

Daewoong, Kim
Kyushu University
dwkim@design.kyushu-u.ac.jp

Tatsuro, Ishii
Kyushu University
tatsuro@design.kyushu-u.ac.jp

Study on Enhancement of the Creative Field in Music Education

Create an Opportunity by Interactive Art



Abstract
Japanese music education is composed of "Appreciation", "Common knowledge" and "Representation". In this last one, the fields of singing, instruments, and creation are included. However, current education programs are built around singing and instrumental activities, and there has been a lack of improving the creative field. In this study, an interactive art installation was developed in order to offer an opportunity for children to enjoy playing with sounds. In addition, considerations about how to connect this kind of activities to the school curriculum are made. The ultimate goal of this study is to engage children in sound and music, and to make an approximation on how to enhance the creative field in the current education program.

Keywords: Music education, Creative field, Interactive art

1 Background

1.1. The Creative field and music education in Japan

Japanese music education is composed of "Representation", "Appreciation" and "Common matters". The fields of singing, instruments and creation are included in "Representation" [1]. (See Figure 1)

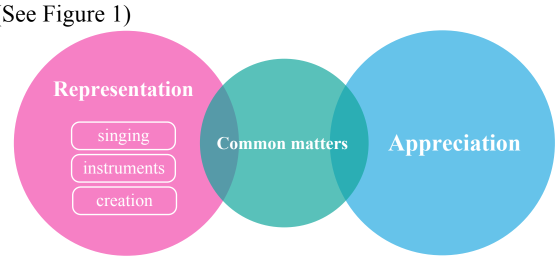


Fig. 1 Configuration of music education in Japan

It is mentioned that in the creative field, children should "find interest in the sounds from the voice and things around themselves, and play with them". It is also important that "by having fun using sounds to make music, musical structures should be shown, and create easy compositions".

Nevertheless, the current education program is focused in singing and instruments, and there has not been sufficient emphasis regarding the creative field.

In a related research [2], a questionnaire took place in order to investigate the children's interest in music. The results were positive on the singing, instruments and appreciation fields for most of the respondents. However in the creative field, the number of positive answers was cut in about half. (See Figure 2)

Causes of this problem include the lack of specialized knowledge and anxiety towards the contents of the creative field.

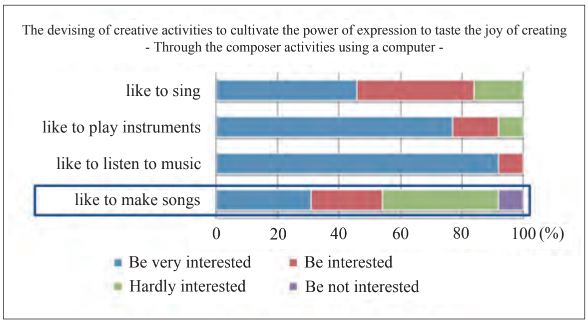


Fig. 2 Results of the questionnaire of the related research

Several studies have been made around this problem; however there has not been any around the idea of making the act of composing a musical piece fun. Some of these studies part from encouraging the children's interest in the sounds from the voice and the things that surround one, as mentioned in the creative field. Also, many focus on interesting the children in sound through acts of play. Although many of these only stay in the teaching method and those with verified practical content are scarce.

This research parts from the concept that by increasing opportunities for the children to get in contact with sounds and enjoy playing with them they will be interested in the act of making music, leading to an enhancement on the creative field of music education. Making music requires making choices about sounds, however these choices are limited in the public spaces of our modern society. This is because the environment is surrounded by multiple noise sources that decrease the possible sounds that can be heard outdoors. As a result, a decline in recognition of sounds has been occurring among children. In other words, opportunities for the children to stimulate their curiosity by interacting with things that surround them have decreased.

From the above, it was concluded that conveying the fun and pleasure of sounds to children had to be a requisite in the present study. Furthermore, since contents with verification were scarcely found in related researches, it was decided to develop contents and test them.

1.2. Interactive art

Technology advancements have brought certain kinds of works that do not fit within traditional art frameworks; from here a new field in art was born. Interactive art is characterized in reflecting the actions of the viewer on itself. Rather than only viewing the art piece, it responds to the viewer in some way. In recent years, Japan has seen a growth in the interest regarding interactive art; in fact the media arts field's budget has seen an increase [3].

Mochizuki, who is an associate professor of Ritsumeikan University in Japan, provides problem-solving opportunities by taking advantage of the characteristics of interactive art [4]. For example, one of his works is a red mailbox equipped with a sensor that reacts when putting inside a letter, and plays nostalgic music related to the postal service, such as "Mr. Goat's mail"[1].

At first glance, these compositions seem useless, however by putting this work in an elderly care facility, it actually becomes a playful way to change the mood of the elderly by hearing old songs every time they put in a letter. This work becomes a trigger, and it leads to new opportunities of exchange between the elderly and their families, and the facilities staff.

In another work, a sensor was placed on the back of a 10 months old baby in order to trace its trajectory while playing and crawling in a room. This trajectory was then presented in visual form as colorful lines. (See Figure 3) By combining movement trails with colorful graphics, an artistic work was made that captured the random behavior of the baby. This transmits a fun picture to the viewer and specially has the possibility of providing a new perspective of the child to his mother.

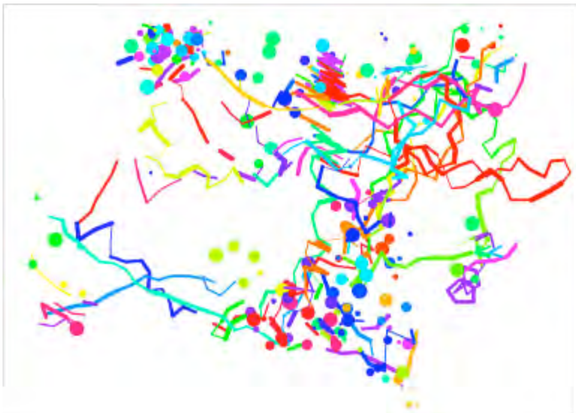


Fig. 3 "Crawling art" captured from a baby's movement

From the examples above, it can be said that although interactive art works do not directly present a method of problem solving, there is an opportunity offered to the viewer in order to get influenced by it. Therefore, the present study aims to create an opportunity for children to enjoy playing with sounds by creating an artwork that uses the characteristics of interactive art.

2 Purpose of study

This study aims to create an interactive art piece that offers an opportunity for children to enjoy playing with sounds. In its development, the following points were taken in consideration.

・An environment that takes advantage of wide space in order

[1] An old popular Japanese song (やぎさんゆうびん).

to offer a joyful experience with sounds for the children.

・An intuitively operable user interface

・A mechanism that can be exposed to volume, pitch, and sound length with a voice interface

In addition, we consider the possibility of connecting fun and play components with learning about sound education, specifically on the creative field. The ultimate goal of this study is to interest the children in sound and music, and to improve the education in the creative field.

3 Artwork Design

3.1. Overview

The artwork developed is an interactive art piece that implements a pseudo-touch screen and microphone as input interfaces. It was designed for children to play without necessarily having knowledge about sound, and it aims to become an opportunity to know the fun and joy of sound. It was called OTONOMI. (See Figure 4)

Fig. 4 Photo of OTONOMI

The ultimate goal is that through experiencing the contents on OTONOMI, children recognize and play with sounds in order to improve the learning on the creative field of music education.

In the first part of the experience, the children are provided with tree fruits on the screen. When the children emit voice into the microphone, the fruits take various forms and change their appearance depending on the sound. The colors and shapes change according to the voice's size, height and length. Once the fruits appear, the children can play the sounds by touching them. (See Figure 5)

Fig. 5 Children using OTONOMI

The title "OTONOMI" means, "Sound fruit". It was created from the concept of sounds hanging from a tree. It expresses the idea of originating sounds from one's voice and then using them in order to make a musical performance.

In addition, visual elements that could grasp the children interest such as changing scenes and interactive animals were incorporated. It was also added the possibility of participating more than a single person: up to three users can interact at the same time and the installation react accordingly.

OTONOMI was designed in a way that let children play without requiring any specialized knowledge, so it aimed at presenting an opportunity to know the fun and enjoyment of sound. What differentiates this artwork from others is that in OTONOMI a microphone is used as an interface input, and lets the users select the size, length and height of the sounds. Then, it was possible to play with these user-generated sounds in any desired way through touching them in the screen.

3.2. Layout of the Art installation

The layout of the art installation is as shown below (See Figure 6). The touch interaction is made through a projector along with a Kinect™ sensor. The microphone for voice input is put in a way that lets the viewer contemplate the projection and avoid capturing the sounds emitted from the speakers.

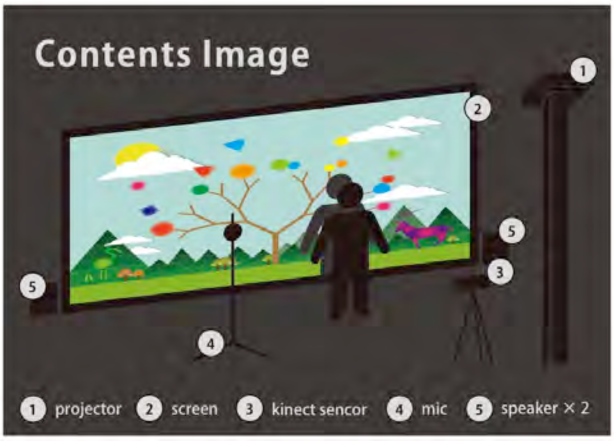


Fig. 6 Layout of the art installation

3.3. System Design

A flow chart presenting the overview of the system design is shown below (Figure 7).

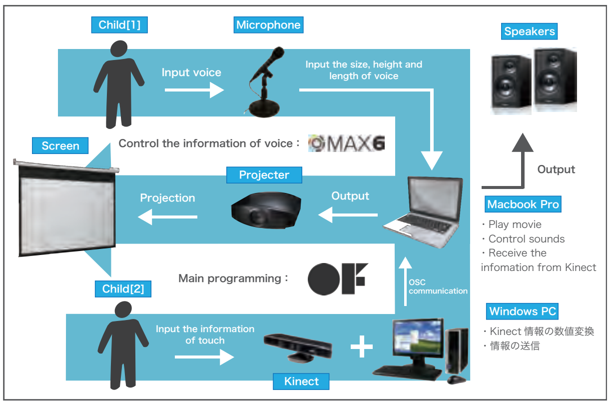


Fig. 7 System design image

The 2D graphics, sounds and information coming from the Kinect™ sensor are controlled using openFrameworks.
The data from the microphone interface and pseudo-touch screen interface coming from the Kinect™ sensor are managed with a PC and a Macbook Pro as shown in the picture.
Voice analysis is made using Max on the Macbook Pro, and the Kinect™ data is analyzed using Kinect™ for Windows®.

Data management between Mac and PC is achieved by using the OSC communication protocol.

4 Development Process

4.1. Tree design and implementation of physics engine

The creation of OTONOMI started its visual design around the concept of a tree. The work "KYOTO"[5] produced by FunkTronicLabs[2] was studied as reference. In this work, Leap Motion™ is used for manipulating sounds in an interactive space. A custom engine based on C++/OpenGL is used for this project. The concept of the tree, its aesthetic value and use of physics engine were taken in consideration for this research production.

Fig. 8 Picture of "KYOTO"

The physics engine that affects the movement in the tree of "KYOTO" uses the Verlet algorithm. (see Figure 9) This formula is used to calculate trajectories of particles in molecular dynamics.

In simple terms, while most physics engines determine the speed from the acceleration and define the position, the Verlet integration calculates the speed difference between the current and previous positions, and then determines the next position.

$$\vec{R}_I(t+\Delta t) = 2\vec{R}_I(t) - \vec{R}_I(t-\Delta t) + \frac{\vec{F}_I}{M_I}(\Delta t)^2$$

Fig. 9 Formula of the Verlet integration[3]

The benefits of using the Verlet integration are that it can move objects with less programming code and that expressions such as elasticity are easy to handle. Also, the reaction to collisions in the tree of "KYOTO" is very smooth; it is capable of producing a natural atmosphere.

We wanted to achieve this kind of natural reactions in this project, so it was decided to implement the Verlet Integration for the physics engine.

Also, this program drew fractals using recursive functions in order to produce a model of the tree in the program. (See Figure 10) The fractal is a shape that reproduces itself while being reduced in size but maintains the original form. The recursive function is a function that calls itself from within itself in order to achieve the fractal's appearance.

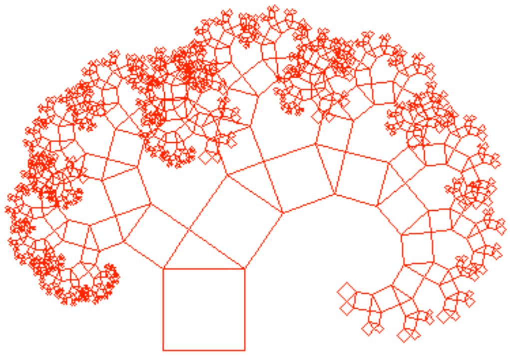


Fig. 10 Sample of a fractal

4.2. Fruit's sounds, music and instruments sounds

The tree fruits are drawn as basic geometric figures. The color of the figure represents the height of the sound. If it is a high sound it becomes red and if it is low, it becomes blue. (See Figure 11)

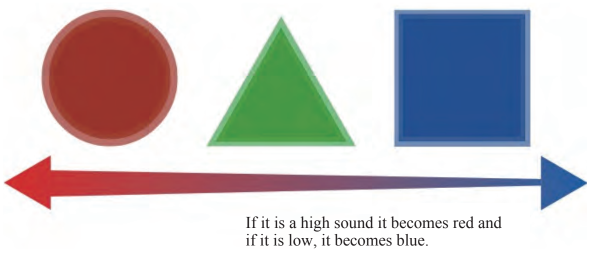


Fig. 11 The tree nuts of sound

Children were given the freedom to perform with the sounds stored in the fruits along three scenes.

The generated fruits could be dragged into the main part of the tree in order to connect them through branches. Some improvement regarding the animations in this point was still needed in order to be more appealing for the children. (See Figure 12)

[2] A studio that "focuses on delivering creative experiences through games, VR and other interactive media", as presented in their website.
[3] In the formula, position is R, mass is MI, force is F, and t is time.

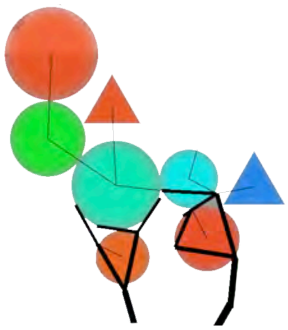


Fig. 12 Appearance of the tree nuts of sounds connected

The sounds that come from interacting with the tree nuts, along with the background music, were produced using the Logic Pro X software. The production of music and musical instruments was very important since it was necessary to make the sounds created by the children pleasing. For this purpose, an ambient sound was selected, that maintained a pleasing atmosphere even with the cacophony of sounds produced by the users. The sounds assigned to the fruits were based on three different instruments that could be appropriated easily by the children. Also, these sounds were considered as capable of repeating rhythmic patters that wouldn't become unpleasant sounds.

4.3. Microphone input system

A program that calculates the voice input that affects the sound of the tree fruits was made using the Max software. With microphone input, the children can choose the sound size, height and lenght easily. The voice's information is decomposed in size, lenght and height through openframeworks in order to be reflected on the tree fruit's sounds.

The size affects the speed of the fruit being generated, the voice height affects the color and the height of the sound when the fruit is touched, and the lenght affects the fruit's size.

Also, other elements were incorporated in order to motivate children to try different voices. For example, the color of the fruit varies by continuously performing in the microphone input and changing the height of the voice.

4.4. Pseudo-touch screen

A pseudo-touch screen was used in order to provide an intuitive interface. The pseudo-touch screen is a technique that uses a projection on a wall or screen and combines it with a movement sensor such as Kinect. The pseudo-touch screen does not present great difficulty to make, however depending on the site where it is placed, the interaction response can change in various ways, and so it was necessary to make adjustments at the moment of presentation.

An example of the pseudo-touch screen is shown below. (See figure 13)

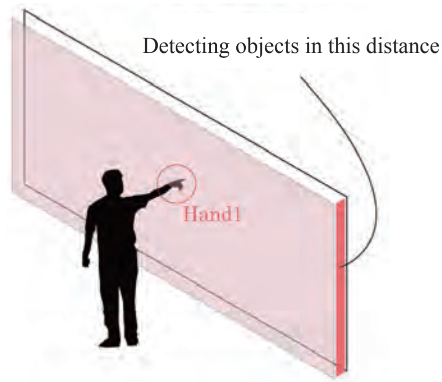


Fig. 13 The pseudo-touch screen technology

Only a small range of distance is used for the movement detection. The computing process is as follows.

1. Detect with Kinect™ if the distance of the object in front is constant.
2. The system assigns a number to the detected object in its appearing order (Hand1, Hand2, etc.)
3. The touched objects are detected and this information is sent through OSC from the Windows PC to the Mac.
4. The Macbook Pro receives the OSC message and draws the graphics.

Based on this process flow, we produced a program for the touch detection. (See Figure 14)

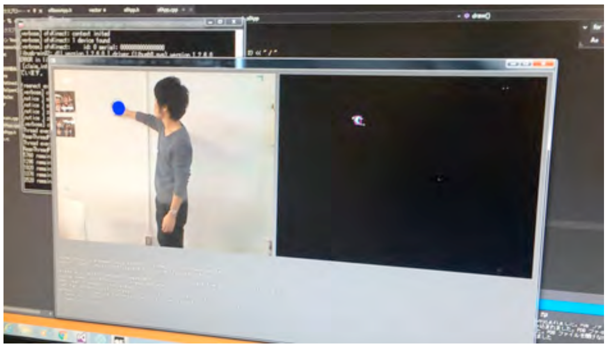


Fig. 14 Complete touch screen program (Windows side)

4.5. Communication through OSC

For the creation of OTONOMI, a Windows PC was necessary in order to use Kinect™ for Windows®, however openframeworks needed to be coded using Mac. For this reason, we created an environment in which the data could be exchanged between Mac and Windows PC using OSC communication. The Windows side transmits the coordinates of the object detected by Kinect™, and in the receiving Mac side, the data is converted into the coordinates of the screen. Although, the problem in this phase was the resolution of Kinect™ v1, since it was lower than the projector's which caused a less precise recognition. This problem was resolved by doing a numerical conversion that permitted matching both resolutions.

4.6. 2D graphic resources

After building the system, graphic resources were planned in order to determine an overall atmosphere of the installation. At first, 3D graphics were considered, but in order to make a friendlier design for children of early ages, a 2D design was preferred.

With the objective of making a design that would not tire out the children, a background scene was designed that alternated between a clear day, rain and night. (See figure 15) The scenery doesn't include any interactions, only animations of the clouds moving.

Fig. 15 Background movie: clear day, rain, and night

Additionally, animals were put in each scene in order to include more variation. When the animals were touched, a small animation was played along with the animal's sounds. With this component, it was aimed to increase the interactivity component by also offering children the possibility to interact with the environmental sounds. The animals created are shown below. (See figure 16)

The visual design of OTONOMI was planned to have a cheerful tone in order to be friendly for the children. All of the 2D visuals, including the sceneries, animals and the fruit's symbols were designed in this way, with bright color palettes and smooth animations. This was in order to transmit a richer and more entertaining experience in the moments of interaction when touching the fruits and the animals.

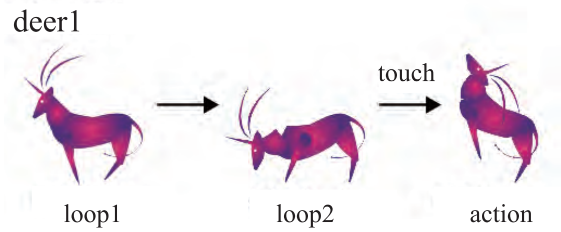


Fig. 16 Animals from the "clear day" scene, a deer

4.7. Additional implementations and final adjustments

With the points explained above, the interactive elements of the installation were ready, and it was possible to experience it. Therefore, it was decided to include additional elements in order to capture the children's interest and improve the quality of the installation. These are:

・A visual effect when something is touched.

・This effect changes when more than one person uses the microphone.

The effect for the touch detection looks like an explosion of shapes with its center located in the coordinates of the detected touch. (See Figure 17)

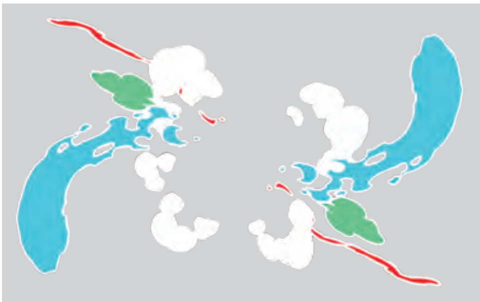


Fig. 17 Effect when children touch the tree fruits

On the other hand, when multiple persons made voice input via the microphone, a big effect that covered the entire screen appeared. (See Figure 18)

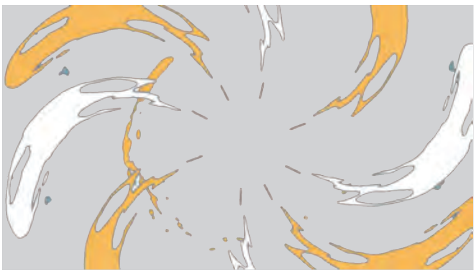


Fig. 18 Effect on the entire screen

After the contents production was completed, an experiment took place with the finished version of the program that included all of the elements explained above. Final adjustments were made, such as the microphone input controls, the screen size, and the speed of the touch response. (See Figure 19)

For this final phase, the children's experience conditions were contemplated, and considerations about the size of the tree fruits and the screen size were especially critical.

It was also necessary to adjust the location of the Kinect in order to correctly detect the hands corresponding to the position of a child's height. Furthermore, when the fruits were touched, the hand's shadow would cover them, so it was necessary to find an appropriate minimum size of the fruit in order to be visible when manipulated.

Adjustments on the same day of the verification experiment were also made, since the variation of the children's movement, height, and voices affected the experiment's site.

Fig. 19 Final version of the program

5 Verification

A group of children was selected to experience "OTONOMI" in order to verify whether the installation led them to enjoy playing with sounds. The main objectives of the verification experiment are as follows.

1. Whether the children were able to enjoy playing with sounds in "OTONOMI".

2. Whether the input interface was easy to handle by their voice and touch.

3. Whether children would enjoy making music in the future.

4. Examine the effectiveness of the content for providing an opportunity to enjoy being creative, and find points for improvement.

The tested children were asked to evaluate the installation by filling surveys after they experienced "OTONOMI". This survey presented questions about their impressions towards the installation and what they felt about the creation interface.

The survey (see Figure 20) had six items; five were quantitative answers and the last one was an open answer.

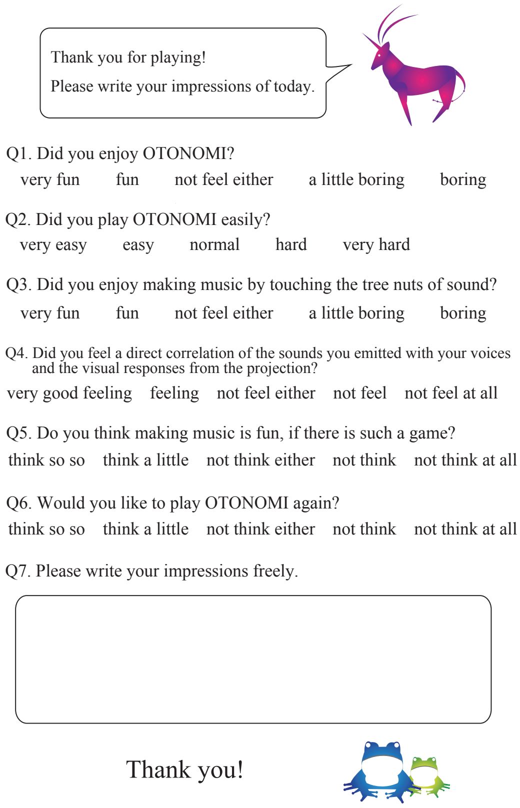
The verification experiment took various groups, each of two or three children that played with "OTONOMI" at the same time. The details of the experiment are as follows.

・Date: January 23, 2016

・Location: Fukuoka Municipal Miyatake Elementary School, in the after-school care take program.

・Method: Fill out surveys after experiencing the installation.

・Subjects: 15 Elementary school children between grades 1 and 4.



Thank you for playing!
Please write your impressions of today.

Q1. Did you enjoy OTONOMI?
very fun fun not feel either a little boring boring

Q2. Did you play OTONOMI easily?
very easy easy normal hard very hard

Q3. Did you enjoy making music by touching the tree nuts of sound?
very fun fun not feel either a little boring boring

Q4. Did you feel a direct correlation of the sounds you emitted with your voices and the visual responses from the projection?
very good feeling feeling not feel either not feel not feel at all

Q5. Do you think making music is fun, if there is such a game?
think so so think a little not think either not think not think at all

Q6. Would you like to play OTONOMI again?
think so so think a little not think either not think not think at all

Q7. Please write your impressions freely.

Thank you!

Fig. 20 Survey

The survey results show positive responses so the purpose of this verification was satisfied. (See Table 1) From this, it can be said that it was possible to give the opportunity to children to know the fun and pleasure of sound through the interactive artwork created for this study.

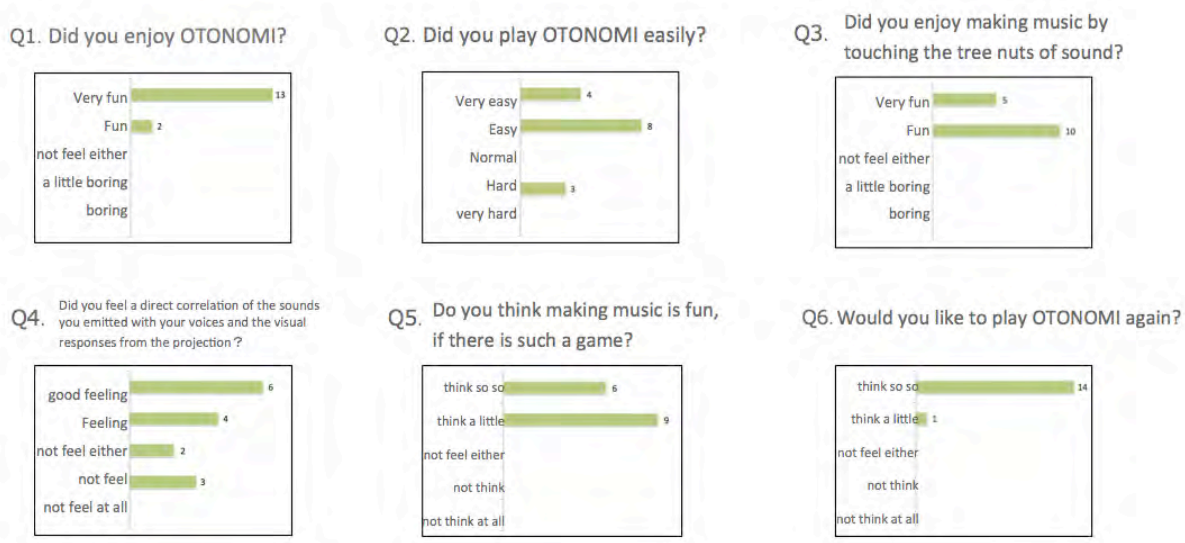
Furthermore, the evaluation pointed to improvements that could be made in various points in order to make the interactive art experience better.

First, the most serious problem was the reaction of the touch operation. In this work, the reaction speed was reduced in order to prevent many sounds to play at the same time and causing a sound discord. However, this seemed to be frustrating for the children. From this, we can conclude that adjustments are necessary in order to proportionate freedom to use the installation with any desired speed. It would be also important to find a way that the multiple sounds don't cause an unpleasant cacophony.

From the question Q4, we concluded that the children did not feel a direct correlation of the sounds they emitted with their voices and the visual responses from the projection. It would be necessary to make clearer graphic responses towards the voice input.

Regarding the opportunity intended to be offered by the installation for having fun interacting with sounds, according to the surveys responses alone, it could be concluded that the children felt interested in creating music in the future. Also, after the surveys, some interviews were made and we learned that the children had interest in matching the sounds they

Table 1 Results of Survey



made with the background music in order to make an appropriate musical response. From this we could say that after experiencing the installation, the children's interest towards sounds and music was increased.

In the future, it is desired to investigate how the experience with this installation affects the interest and attention of the children towards the school's music classes. For example, take two groups of students, one that have experienced the installation and the other that doesn't. Then, make them take a music class related to the creative field, and compare their results in order to determine the impact of the installation.

6 Conclusions

In this study, we focused on the problems of the creative field in music education and found that it was necessary to research about a practical way to transmit the fun of playing with voice and surrounding sounds to children. Furthermore, we found that the contact that children have with surrounding sounds has been decreasing. For this purpose, an interactive art installation was created in order to offer children an opportunity to get to know the joy of creating sounds.

The purpose of this study is to connect the opportunity offered by the interactive installation with the creative field of music education in order to enhance it. With the verification experiment, the effectiveness of capturing the children's interest and responding actively in the creative field was tested.

The results showed a positive response towards the experience and showed that they had fun with the installation. Children got immersed in the activity, and they could be seen interacting with the microphone and touch screen repeatedly.

Furthermore, the children were aware of the change of sounds related to the color of the tree fruits and tried various sounds with their voices by themselves, without any previous explanation. Based on the above, we proved the possibility of creating this kind of opportunities through an interactive art installation.

It can be said that it was possible to attract the children's interests because the scores of the items on the survey that inquired about their enjoyment had high evaluations.

However, the response of the questions related to the operation of the installation showed that some problems of the user interface and technical issues remain. The following improvement points were identified.

・Improve the design of responses to the interaction of the children, specially regarding the microphone input.

・Improvement and election of an optimal interface.

・Clearer reactions towards the children's voices and movements.

Our current society is overflowing with information, and this has an impact on the current generation. Young people are tending to lack ambition and desire, this have been called the "Satori" generation in Japan. We have though the work described in this paper to be directed towards this phenomenon, in order to engage the students and motivate their imagination for better ways of transmitting education. In the future, it would be desired to spread the use of this kind of interactive art installations, with works that can convey joy to the children and improve from the one presented in this paper.

References

[1] The Ministry of Education, Culture, Sports, Science and Technology, *The commentary of course of study in elementary school*, pp. 9, 2008.

[2] Katsuya Fujiwara, *The devising of creative activities to cultivate the power of expression to taste the joy of creating -Through the composer activities using a computer-*, Teachers long-term training in Hiroshima Prefectural Education Center, pp. 58 - 59, 2004.

[3] Sachiko Imaoka, *The possibility of media art promotion policy in Japan*, 2011.

[4] *What to bring*, http://www.1-click.jp. (2016/01)

[5] *FunktronicLabs*, http://funktroniclabs.com. (2016/01)

International Journal of Asia Digital Art and Design Vol.20

No.01 Date of issue 2016/04/02

Asia Digital Art and Design Association

Designed By Iwamoto, Yushi

Edited By Nagisa, Niwata
Shiori, Hidaka

Published By

Asia Digital Art and Design Association

c/o Tokyo Metropolitan University

6-6, Asahigaoka, Hino-shi, Tokyo, 191-0065, Japan

http://adada.info adada.post@gmail.com