

## Visual Surveys with Purposeful Games

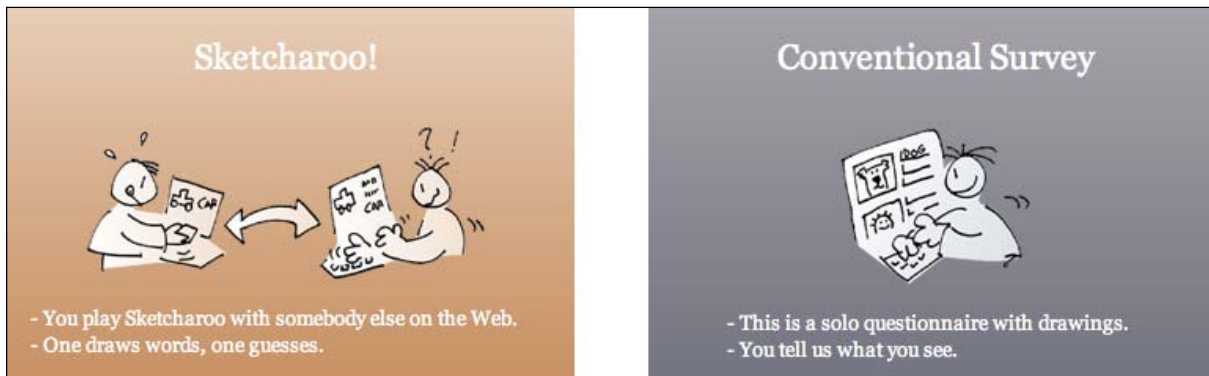


Figure 1. Detail of the home page of our platform, offering visitors the choice between the purposeful game *Sketcharoo* (left) and the *Conventional Survey* (right).

Keywords: Games with a Purpose, Interaction Design, visual communication, visual surveys, gamification

### Abstract

In 2004, von Ahn and Dabbish introduced and developed the concept of "Games with a Purpose" (GWAPs). Since then, several applications for these games have been created and evaluated. In this article, we present an experimental framework for visual surveys which allows for both creative and analytical inputs. The framework consists of such a GWAP, our game *Sketcharoo*, combined with a conventional survey as a feedback loop for the drawings we were able to gather. *Sketcharoo* aims to engage the creativity and subjective judgement of its participants, in a way which separates it from most existing GWAPs.

Both instruments, the game and the survey, helped to gather in a very short time more than 10,000 drawings and more than 24,000 terms or guesses. In this article, we will briefly present the background of GWAPs; our experiment design and results, including our mistakes; and a discussion, with suggestions for future projects using this approach. The web-based applications *Sketcharoo* and the *Conventional Survey* are both available for use and evaluation online at [www.sketcharoo.com](http://www.sketcharoo.com)

In early 2012, New York-based game developer OMGPOP posted the mobile versions of his game *Draw Something* (Zynga, 2012). The game is a modern reinterpretation of the classic board game Pictionary: participants try to guess the meaning of other players' drawings or to draw words given to them. Only 50 days later, the game hit the 50 million downloads mark, making it the fastest growing mobile game ever. Social gaming giant Zynga bought the developer six weeks later for \$210 million. Apparently millions of online gamers hugely enjoy drawing and guessing words with friends.

In 2008/09, we undertook a research project at the University of Otago in Dunedin, New Zealand, developing a very similar game called *Sketcharoo*. In our case, however, we developed *Sketcharoo* as a "Game with a Purpose" (GWAP), a game with an additional purpose beyond mere enjoyment. *Sketcharoo* was planned as a tool for visual research and surveys. Annoyed by rampant textual and numeric online questionnaires, our intention was to create a more playful, creative tool that allowed other forms of expression. The idea was to come up with a tool that would invite survey participants to do more than just filling out text boxes, ticking check boxes, or answering Likert scales. At the same time, we tried to use the principles of video games embedded in the so-called GWAPs. We wanted to create a game that was both fun for the players and that served an additional purpose behind the scenes.

In order to compare the results of our game with more traditional, drier survey types, we added a deliberately sober online questionnaire – the *Conventional Survey* – to our website. In this, we asked participants to label images derived from the game.

For visual, creative types, reading or creating images is a pleasant, rewarding mode of communication, and a Pictionary-like drawing game an entertaining pastime. As Hanington (2003) explains, "[t]he benefits of working visually in research may be self-evident to designers, who respond intuitively to the [visual] language and find a more natural transition to design decisions from visual information" (p. 15).

Many people lose this visual literacy and the joy of creating images after childhood, or replace this talent with other interests and skills. In his book *Left to Right: The Cultural Shift from Words to Pictures* (Crow, 2006), designer David Crow picks up on the old idea of the two brain hemispheres, each representing a mode of thinking. In this – a little over-simplistic – model, the right hemisphere stands for pictorial thinking, while the more abstract and rational language of text triggers qualities of the left hemisphere. None of them is ideal alone, and great thinkers and ideas usually incorporate aspects of both. However, it is perhaps fair to question the strong bias for text in academic discourse and to re-emphasize the idea of visual thinking as a valuable addition to this discourse. We would like to mention here only Gui Bonsiepe (1997) as a very prominent and long standing advocate of this "Viscourse" and of the position – fairly obvious for visual communicators – that visual discourse deserves equal rights to textual discourse.

In our GWAP *Sketcharoo*, predetermined terms are translated into more free visualizations of these terms. In the *Conventional Survey*, the images obtained are translated back into text.

A considerable amount of our initial research attempted to measure which of the two instruments was perceived as more enjoyable and was thus, by our standards, the more successful survey instrument. Furthermore, we tried to quantify participant enjoyment by using a simple Likert scale mood rating before and after both the game and the conventional survey. Both attempts failed, regrettably.

Our experiments were not comprehensive enough and the experiment design not generalizable enough for us to identify safely a preference for one or other type of survey. However, it can be said that there were some participants who preferred to play the GWAP *Sketcharoo*, and others who preferred the *Conventional Survey* questionnaire.

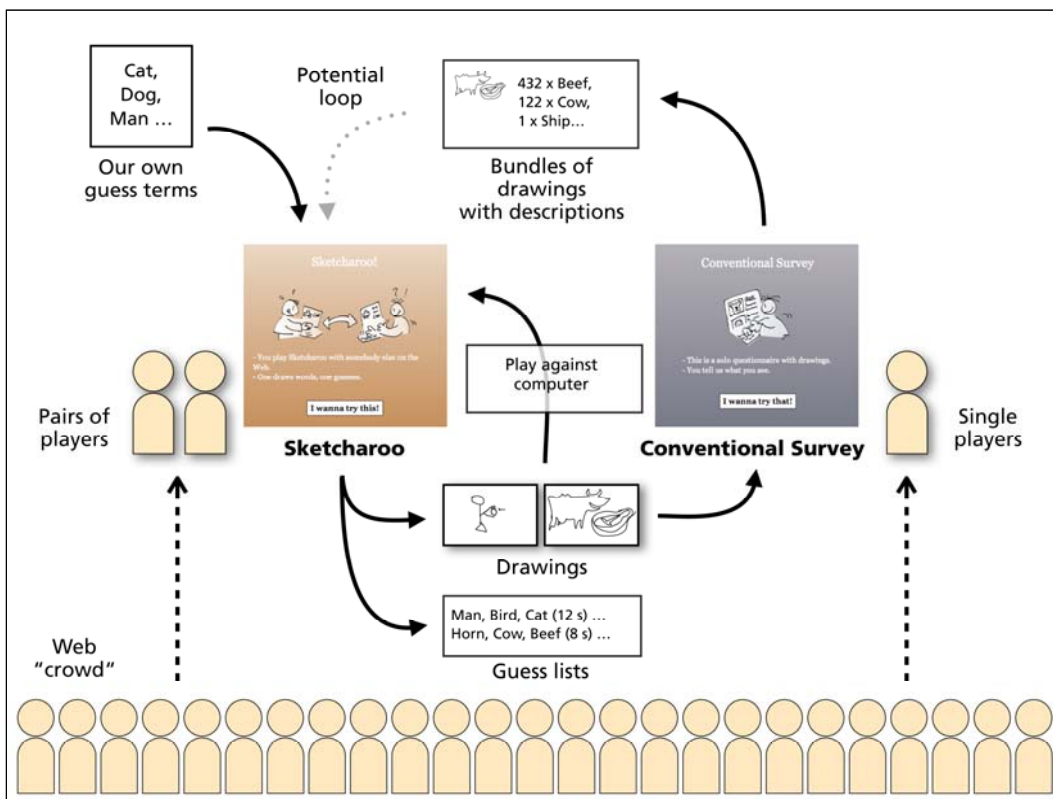


Figure 2. *Sketcharoo* and the *Conventional Survey* form a system for text-picture translations and vice versa. Our experiment started with the introduction of our own guess terms at the top left. It can also be started at any other point.

We realized that both instruments work together as an integrated system which allows verification or refinement loops of the collected data (Figure 2). Both parts can be understood as elements of one shared research platform, enabling comprehensive surveys which are both visual and textual. This research platform combines methods used by web-based online surveys with GWAPs. GWAPs are themselves combinations of crowdsourcing (i.e., the inclusion of a large number of web volunteers)

with “gamification” (where objectives from non-gaming contexts are charged with gaming mechanics to make them more attractive).

With our system, we believe we have developed a promising framework to cope with very diverse and large-scale text-picture translation tasks. These could include general translations of text language to visual language and back, for example for the creation of visual dictionaries or highly specialized maps (for children, people with low literacy levels, people who are not fluent in a particular language, or specific cultural groups). We also foresee direct or indirect applications in design, semiotics or market research, for example to survey associations that specific participant groups have with specific terms or imagery. The platform can also be useful as a research platform or learning tool, for example in disciplines as diverse as semiotics, linguistics, psychology, education, social sciences, and commerce.

### *Serious Games and Gamification*

The language of computer games has influenced other disciplines from science to commerce (McGonigal, 2011; Bogost, 2007; Salen & Zimmerman, 2004). Since the early 2000s, the “serious games” movement has established the relevance of computer games in a number of other areas. Popular examples include simulations for the military, for example the army simulation *America’s Army* (MOVES Institute, Secret Level, & Gameloft, 2002), or for the health sector. “Games with an agenda” have expanded the repertoire of games to education and politics. “Advergaming”, games with advertising messages or agendas, have been recognized as a serious game sub-genre by some authors, although advergaming has been around for considerably longer than serious games.

Since about 2010, the new label of “gamification” has been adopted, partly as a continuation of some of the serious games ideas, but partly also as a counterpoint (Zichermann & Cunningham, 2011). Gamification typically uses methods borrowed from games – such as high score lists; continuous feedback; and constant, increasing rewards – to increase the attractiveness of mundane work or everyday tasks.

These approaches are often combined with methods of crowdsourcing, i.e., the network-based bringing together of huge groups of participants to achieve common goals. The Nike+ (Nikeplus) jogging portal is a popular application of such gamification methods. A transmitter in someone’s own running shoes transfers detailed performance data to the Internet. There it is not only converted into engaging graphics and performance sheets, but also published as a form of open competition, either amongst all other participants or invited friends only. This public listing alone might spark a runner’s engagement, but if this is not enough, a plethora of engaging and funny messages from friends and the Nike+ system motivate the runners to keep running – at least until the novelty of the system wears off.

Gamification is currently a little overused in the industry as some sort of universal remedy. Still, the idea of introducing playful concepts and mechanics to other fields, for example the workplace, has undoubtedly far-reaching potential.

## Games with a Purpose (GWAPs)

The young games sub-genre of GWAPs translates tedious and labour-intensive tasks, such as office tasks or rating music or pictures, into computer-game-like applications, most often by connecting large participant groups online. Von Ahn and his colleagues (von Ahn, 2007; von Ahn & Dabbish, 2004, 2008; von Ahn, Kedia, & Blum, 2006; von Ahn, Liu, & Blum, 2006) developed the research around GWAPs to solve incomputable problems, or problems computable only with complications and poor results. As von Ahn (2007) observes, human computation is "... a paradigm for utilizing human processing power to solve problems that computers cannot yet solve... tasks like image recognition are trivial to humans, but continue to challenge even the most sophisticated computer programs..." (p. 5).

An initial major outcome of the GWAP paradigm was the *ESP Game* (Hacker & Ahn, 2009, p. 1208), an early version of what later became the *Google Image Labeler*. These are online games which let pairs of online players coin descriptive labels for randomly presented pictures to increase the accuracy of image searches.



**Figure 3.** Home page of [www.gwap.com](http://www.gwap.com)

In May 2008, the team around von Ahn launched the website [www.gwap.com](http://www.gwap.com) (Figure 3), which featured an overhauled version of the *ESP Game* along with *Tag a Tune*, *Verbosity*, *Squigl*, *Matchin*, *FlipIt*, and *PopVideo* (von Ahn et al./Carnegie Mellon University, 2008). The GWAP approach is built around the possibilities of swarm-like participant groups, like those that can be found online. In the GWAPs by von Ahn and his colleagues, human participants are used as free processing units handling the splintered subtasks of the larger tasks at hand.

“The games we have designed so far have focused on problems that are easily divided into subtasks. The ‘bite-size’ nature of these games adds to their popularity and appeal to casual gamers in particular, since such players typically go for games they can play ‘just one more time’ without having to make too much of a time commitment.” (von Ahn & Dabbish, 2008, pp. 66-67)

As von Ahn and Dabbish (2008) rightfully point out, GWAPs are in themselves fun (or enjoyable competition): “People play not because they are personally interested in solving an instance of a computational problem[,] but because they wish to be entertained” (p. 60). GWAPs are also very different from serious games, which often translate their serious content into a fairly direct re-enactment of real world scenarios, e.g., training software or engine simulations. In GWAPs, the game task and the outcome can be entirely disconnected and different from each other, and the purpose can remain hidden to the players.

## *Online Surveys*

Online surveys are extremely popular in areas such as social and market research because they are faster and can be immediately processed. Bickman and Rog (2009, p. 26) have summarized some of the advantages found in the use of online surveys which we also observed in our own survey platform: that the collection of data was very rapid; there were no data entry costs, given that the respondents entered their own data; the data was almost immediately available to the researchers; and to increase the completion rate, the researchers could track the rate and respond while the survey was still in the field.

Our survey platform included characteristics that Evans and Mathur (2005) reported to be best suited for online surveys. Also, we think that characteristics 1-4 and 6 below are also inherent characteristics of GWAPs. The characteristics are

- 1) wide geographic coverage,
- 2) a large sample,
- 3) a high frequency of surveys,
- 4) a multimedia approach,
- 5) a lack of interaction with the respondent, since it is not necessary and/or desirable, and
- 6) a timeless environment – if researchers want to be able to examine respondents’ behavior without time constraints, the survey always has to be available.

To these we would add that

- 7) a fast response is needed, and
- 8) researchers should address specific demographics.

These characteristics are discussed in relation to our findings in the following sections.

## *Experiment Design*

As mentioned earlier, we developed an experiment in which we asked online participants to interact with two instruments: our GWAP *Sketcharoo* or the *Conventional Survey*. The selection menu is shown in Figure 1.

Initially, we evaluated existing survey systems that allowed the embedding of visuals in questionnaires. Most of the online survey systems we investigated, e.g., [www.glowday.com](http://www.glowday.com), [www.questionpro.com](http://www.questionpro.com),

[www.fluidsurveys.com](http://www.fluidsurveys.com), [www.stellarsurvey.com](http://www.stellarsurvey.com), and [www.checkbox.com](http://www.checkbox.com), allow only fairly limited use of imagery. Accordingly, we decided to create our own survey framework which would allow any drawings collected in the game to be reused as survey input.

*Instrument 1: The GWAP Sketcharoo.*

*Sketcharoo* is a loose online adaptation of the popular board game Pictionary™. Pictionary-like computer games have been used in other fields of research, and, as mentioned earlier, have again become wildly popular through the game *Draw Something*. These developments will not be further explored in this article, however.

In *Sketcharoo*, two players are randomly paired via a multi-user server, usually without knowing each other’s identity. One player, the “drawer” (or “describer”), is presented with a term from a database of predetermined terms. The drawer then has up to 60 seconds to draw the term in a way that will enable his or her game partner, the “guesser”, to guess the term successfully (see Figure 4). This rule set-up makes our game a GWAP inversion-problem game.

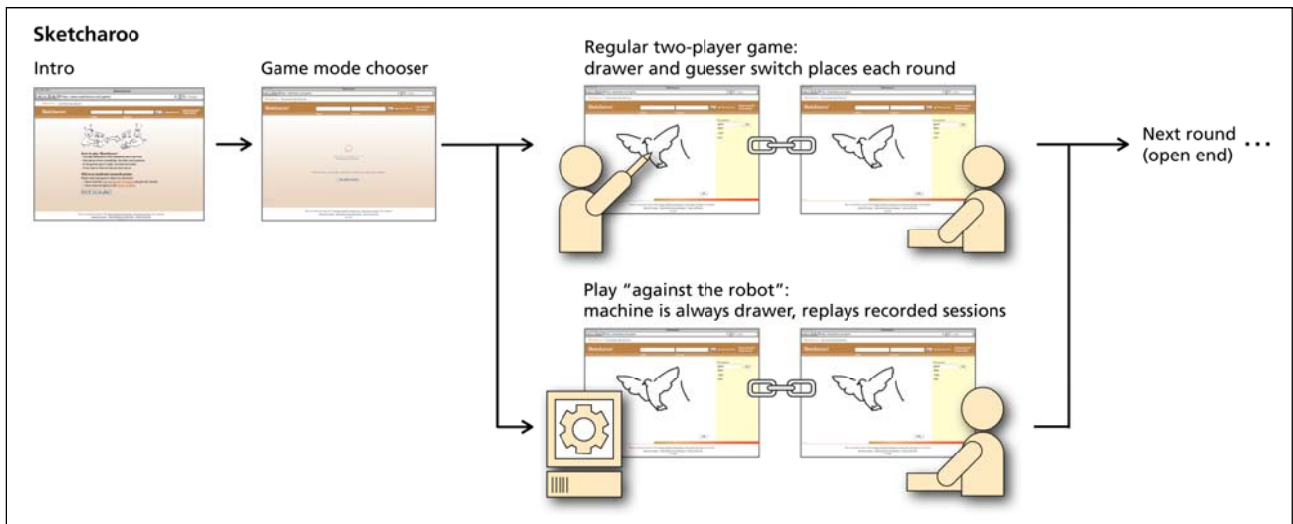


Figure 4. Flow chart of Sketcharoo.

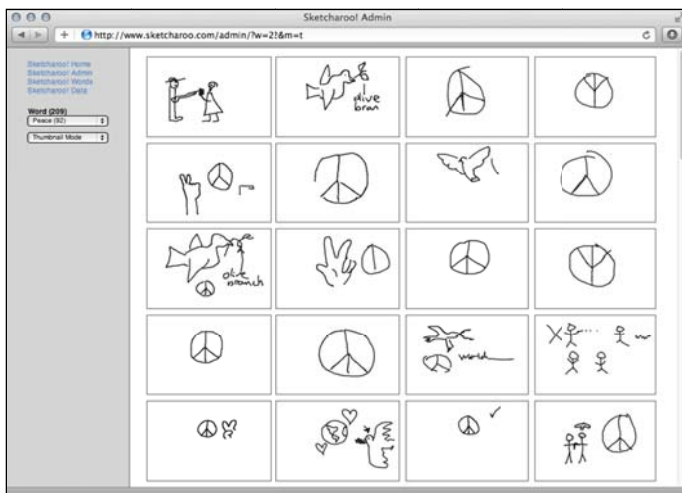


Figure 5. Some of the 92 drawings of the term “Peace” in the database.

The terms in the database range from simple terms like “Apple” or “Cat” to rather advanced concepts like “Peace” (Figure 5) or “Constructivism”. One round takes a maximum of 60 seconds. In the case of a successful solve, both players are awarded the same amount of points. Afterwards, the roles are reversed: the guesser becomes the drawer, and the drawer becomes the guesser. Figure 6 shows the games’ interface.

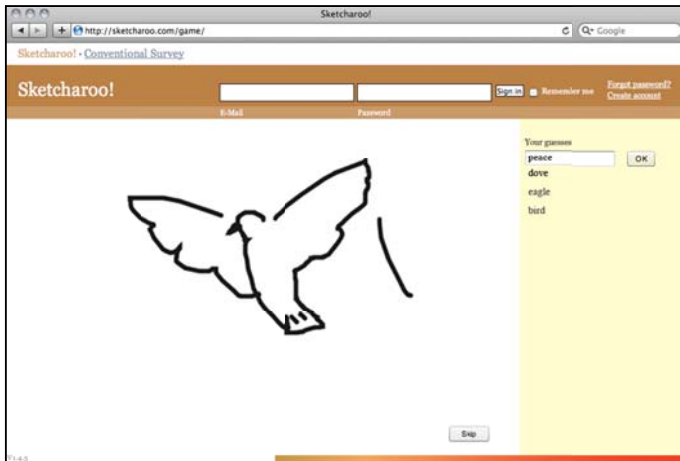


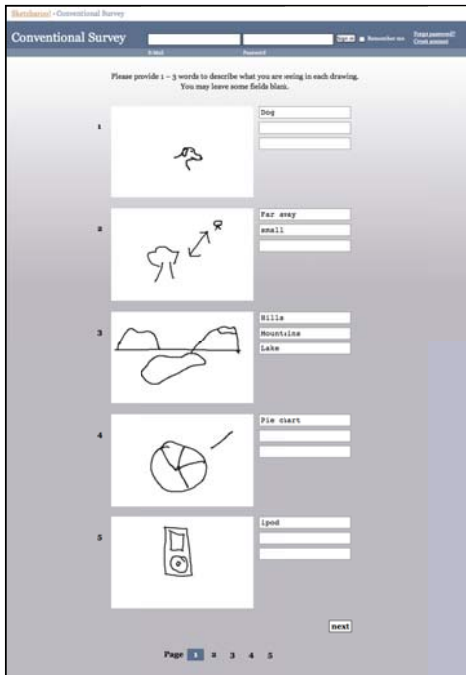
Figure 6. The Sketcharoo interface, showing a drawing for the guess term “Peace”. The panel on the right is the guesser’s text entry field. At the bottom is the timer bar.

Several GWAP mechanisms that optimize player enjoyment and increase participation are present in *Sketcharoo*: timing responses and time limits, score keeping, player skill levels, randomness, and pre-recorded games as stand-ins for human game partners (“play against the robot”) (von Ahn & Dabbish, 2008).

### *Instrument 2: The Conventional Survey.*

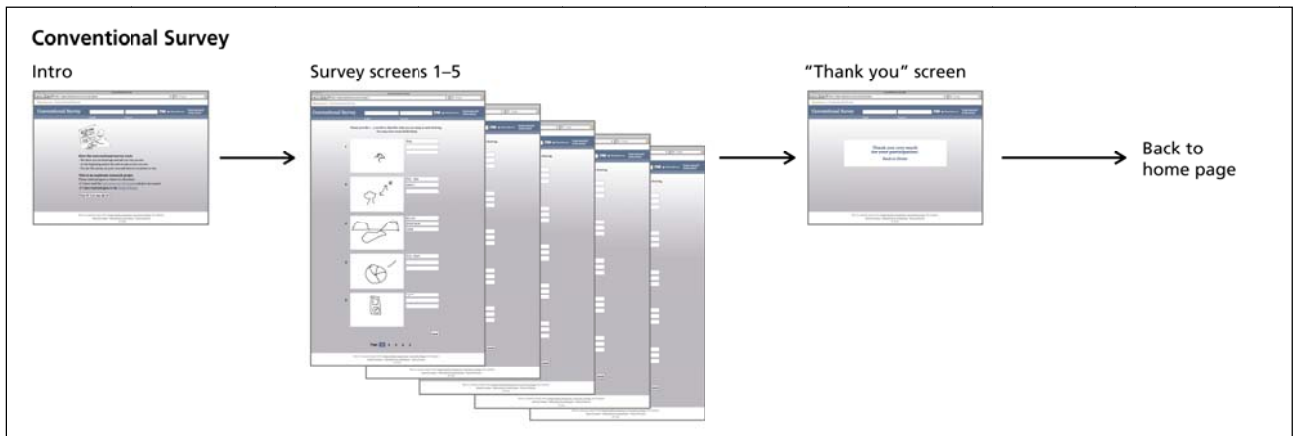
Designed as the counterpart to the multi-user GWAP *Sketcharoo*, the *Conventional Survey* can be filled out alone, at any time, and at the pace the participant prefers. It is a questionnaire with drawings, in which participants are asked to textually label what they see (Figure 7). We used the drawings collected in *Sketcharoo* for the *Conventional Survey*, but any visual material could be uploaded to the database.





**Figure 7. The first of the five questionnaire screens of the *Conventional Survey*.**

The survey is composed of five screens with five pictures each. Each picture offers three text fields that the participants can fill in. They are not obligated to fill in all fields, and can freely navigate the five screens with the “Next” and “Previous” buttons. After the last survey screen, a “Thank you” message appears, together with a link back to the site’s home page (Figure 8).



**Figure 8. Flow diagram of the *Conventional Survey*.**

## Technical Infrastructure

*Sketcharoo* and the *Conventional Survey* are quite different in their structure and in the way participants interact with them. Still, they were built to function on the same server and feed data into the same databases. And, like many crowd sourcing projects, both were designed as small and, hopefully, enjoyable diversions.

### *Data collection.*

Our data collection included survey data from the logs of our own multi-user server, account data provided by the users, Google Analytics data, and the users' feedback regarding their enjoyment. Additionally, and in an unforeseen way, some users occasionally employed the text field for typing guesses during the game as a form of “mini chat” to exchange messages with their game partners. Some of those messages were reports of their enjoyment.

We logged every session and displayed data internally within our own administration system (logs of all activities, including recordings of the drawings as canvas coordinates over time, and the account data provided by our users). An example of these backend overviews is shown in Figure 5.

Initially, our guess term database contained 147 terms, which have now increased to a total of 344 terms. The collection of drawings with their attached text guesses has grown over time, as participants have contributed to it. We were able to feed drawings from the purposeful game *Sketcharoo* into the *Conventional Survey*, and by doing so, to verify the quality of the guessed words.

### *Database and front end design.*

We built our own PHP and Flash framework on a multi-user server maintained under [www.sketcharoo.com](http://www.sketcharoo.com). The PHP framework is the database system that stores the logs of the drawings and text data over time. Adobe Flash acts as a front end interface layer, channeling input from the users and communication events from the server. Adobe Flash is supported by many desktop and mobile operating systems including Windows and Mac OSX, but not by mobile devices from Apple (running iOS). For this platform, we developed a working prototype of an iPhone app of *Sketcharoo* (Figure 9).



**Figure 9.** The iPhone app prototype of *Sketcharoo*.

The different front ends used the same PHP infrastructure, which enabled lab-internal cross-platform tests between players on both desktop and mobile devices. These tests yielded insights about the best input method for the platform.

### *Input interfaces.*

Most desktop computers are still operated with a mouse. It is particularly difficult to draw with a mouse, however, which virtually disqualifies them for drawing games. The widespread laptop trackpads are similarly difficult to use for this kind of application, especially since they have to be additionally clicked (held down) during drawing. Professional graphics tablets with styluses are much better suited to the task, but not very widespread.

At the time of our main experiments, the Apple iPad had not yet been launched, but even from our experiences with the iPhone it quickly became obvious that games like *Sketcharoo* – and drawing games in general – would benefit enormously from the direct, intuitive, finger-drawing method facilitated by that these multi-touch devices. While Smartphones like the iPhone and Android phones are a little bit small for comfortable drawing, they easily make up for this with the advantage of constant availability. Many crowdsourcing projects are designed specifically as diversions during a short break or waiting time. Mobile devices are extremely well suited for this scenario. For applications that also require drawing, capacitive multi-touch devices are a match made in heaven.

## *Discussion*

### *Participant demographics.*

The website [www.sketcharoo.com](http://www.sketcharoo.com) was launched on 1 November, 2009. We ran experiments A, B, and C between 20 November, 2009 and 24 January, 2010 with a total of 3,976 unique visitors (Table 1).

Table 1

### *Dates and participant groups of the three experiments*

<b>Experiment</b>	<b>Observed period</b>	<b>Participants</b>	<b>Unique visits</b>
A	20–22 November 2009	Visitors to <a href="http://jayisgames.com">jayisgames.com</a>	2,560
B	21–23 December 2009	Visitors to <a href="http://www.allmyfaves.com">www.allmyfaves.com</a>	1,291
C	22–24 January 2010	Members of <a href="mailto:phd-design@jiscmail.ac.uk">phd-design@jiscmail.ac.uk</a>	125

All three experiments were dominated by far by participants from the USA (56.1%), followed by Canada (8.6%), the United Kingdom (6.7%), Hong Kong (4.9%), Australia (3.0), Germany (2.8%), and France (1.6%). One of the earliest motivations for this research project was to help with designing visual translation and communication systems. As such we are working in a research area loosely following the tracks of Otto Neurath's "Isotype" and Charles K. Bliss' "Blissymbolics", both accessibly compiled and presented in Crow (2006).

With this background and agenda, it was exciting and important for us to learn about the cultural backgrounds of our participants. It is not surprising that we barely reached non-English speaking participants, as we provided all website content and our invitations exclusively

- textually,
- using the Roman alphabet,
- in English, and
- on Internet-based communication channels (Internet forums and a mailing list).

We cannot elaborate on this in this paper, but we are aware that we did not reach entire cultures with our investigation, most notably Asian, Indian, and African cultures. We seek to open our investigation to these cultures in upcoming research.

The demographics indicate that, as with any other Internet survey, ours had both strengths and weaknesses (Evans & Mathur, 2005). The major strengths were global reach and large samples. The major weaknesses were the skewed attributes of the Internet population, even though the Internet is developing as a true mainstream medium.

The total number of drawings gathered with the GWAP *Sketcharoo* supports Hanington's (2003) claim regarding the advantages of using visual survey instruments: "... [W]hen participants are invited to assist in research by engaging in a creative activity, the response is likely to be more favorable than when faced with a request to fill out a survey or take part in an interview" (p. 15). Or as Langford and McDonagh (2003) observe,

"Drawing can be an extremely versatile and powerful way of enabling individuals to generate and communicate ideas. When people draw their ideas, the outputs often contain details and concepts that are not easily described verbally... The completed drawings are valuable stimulus for further discussion and elaboration of developing ideas... Drawing activities are fun, stimulating and thought provoking." (p. 196)

*Preference, duration of stay, and enjoyment.*

Our initial research questions were, “Are the two survey instruments enjoyable? Is one more enjoyable than the other?” Unfortunately, none of our research instruments provided conclusive answers to these questions.

There was a preference for the GWAP *Sketcharoo* in all three experiments (Experiment A: GWAP 61%, Conventional Survey 39%; Experiment B: GWAP 54%, Conventional Survey 46%; Experiment C: GWAP 58%, Conventional Survey 42%). However, because we had advertised for participants on games-related websites, these figures are unlikely to be representative.

Time spent with each instrument turned out to be an unreliable criterion for the level of fun perceived by the participants. Web pages can be left open in the background or forgotten, and even constant activity on the page or in the application is still not an indication of the enjoyment experienced by the participants.

Our third instrument was the so-called *Mood Rating Scale*. This was a Likert scale with emoticons (smileys) only. With this, we tested the participants’ mood at the beginning of and a few minutes into each instrument. Again, it did not provide sufficient data to answer satisfactorily the question of how much visitors enjoyed *Sketcharoo* and the *Conventional Survey*. Large groups of participants with unchanged moods (game A+B: 41%, survey C: 50 %) leave us wondering if the *Mood Rating Scale* was perhaps too crude, or if we have a strong case of central tendency bias. Generally it does not seem to be a successful tool and we would not recommend its use.

These results helped us to realize that we had actually provided two sides of one coin, and that the surprisingly similar acceptance of both instruments is in fact an advantage. The two instruments add up nicely to one survey platform, capable of attracting participation from two different user types: those enjoying games and those preferring more conventional survey designs.

### *Sketcharoo: a GWAP for creative tasks.*

The GWAP *Sketcharoo* is an example of a type of GWAP with tasks which both require and allow players to use their creativity, express diverse viewpoints, and provide perspectives that generate the broadest set of outputs. As Ahn and Dabbish (2008) reflect:

“The game templates we have developed thus far have focused on similarities as a way to ensure output correctness; players are rewarded for thinking like their game partners. This approach may not be optimal for certain types of problems. In particular, tasks that require creativity, diverse viewpoints, and perspectives are optimal for generating the broadest set of outputs.” (p. 66)

Despite the similarities, our project has a different background to von Ahn’s, and we aim for quite different outputs. Von Ahn and his team come from a computer sciences background and put the emphasis on large-scale problems and tasks that computers cannot *yet* solve, most notably AI research and pattern recognition. Coming from a communication and interaction design background, we focus

on smaller-scale problems and tasks that *only* humans can solve: tasks involving human creativity, language, and subjective human judgement, translated into the methods of multiplayer online gaming.

Unlike von Ahn and his team, we are not particularly focused on correctness or the output accuracy of the translational acts we record, because there is no wrong communication in our experiment. As expected, our data – and especially the drawings – is less standardized than von Ahn’s.

Where a verification of the output accuracy is needed, we suggest, like von Ahn, the use of crowd-sourcing platforms like *Amazon mTurk* for the purpose of result verification and qualification. In another paper (Hebecker & Ebbert, 2010), we have shown a way to verify parts of the results with quantitative data mining.

### *Limitations of game utility.*

Fun, albeit hard to measure, is one of games’ biggest strengths. Efficiency is usually not. This is not too surprising: games are by definition artificial obstacles or conflicts (Salen & Zimmerman, 2004; Juul, 2005) which players choose to tackle and overcome voluntarily. The players’ gain is the fun, satisfaction, and sometimes learning from this: the loss is the large amount of time this usually consumes.

It is debatable if the work done in serious or purposeful games could not be achieved faster with traditional, paid work. The sheer mass of verification loops necessary in most GWAPs eats up a large amount of “human computation” hours. Von Ahn and Dabbish (2008) have reflected on this issue.

“Because a GWAP is a game, ‘fun’ must also be included. It does not matter how many problem instances are addressed by a given game if nobody wants to play. The real measure of utility for a GWAP is therefore a combination of throughput and enjoyability.” (p. 66)

A general problem with games is that their perceived enjoyability depends largely on the degree of freedom of the participants: mandatory, paid, or goal-oriented play is rarely as enjoyable (or not play at all). This limits the usefulness of GWAPs, or at least creates new challenges of acquiring and nurturing large, motivated volunteer bases.

### *Future Work*

The following steps should be taken for future study designs.

- We should address the skewed country demographics and actively seek participants from non-textual, non Roman-alphabet, non-English speaking countries. These participants could be found by localizing our website content and sending out localized invitations in media other than solely the Internet.
- We can foresee effective ways to analyze the quantitative data we have gathered with our systems. For the drawings, we are building our strategy on informed human screening and validation, e.g.,

via *Amazon mTurk*, rather than on automated image recognition. The *Conventional Survey* is already an instrument performing in this way.

## Conclusion

It appears that survey research has not yet fully embraced the advantages of designing visual and ludic instruments in the language of social online media. With our combination of the GWAP *Sketcharoo* and the *Conventional Survey* we have developed an alternative to existing online survey models and hope to add a facet to the repertoire of scientific and commercial survey research.

We see this contribution as twofold. Firstly, we provide a more playful and potentially enjoyable vision of how future online-based surveying can work and what it can look like. Secondly, the game-like characteristics of *Sketcharoo* introduce the reward models of video gaming and purposeful games into surveying.

There are limitations to the GWAP paradigm, as there are to the gamification of work tasks in general. Still, we see huge potential in the GWAP model, especially for those applications not just using the participants as human computation units, but involving “real” human creativity. The playful and intuitive direct user experience and the enjoyment experienced by the participants, the large and fast reach, a potentially massive throughput, and the whole paradigm of work wrapped into casual, collaborative games are a powerful combination worth further exploration.

## Acknowledgments

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