Gameful Learning for a More Sustainable World –

Measuring the Effect of Design Elements on Long-Term Learning Outcomes in Correct Waste Sorting

Greta Hoffmann, Jella Pfeiffer

Appendix (available online via http://link.springer.com)

Experimental Procedure – Detailed

P1*:* After closing the registration for participation in the experiment, we randomly assigned participants to one of the five experimental groups in a between-subject design. We sent instructions via email for participants to fill out the first survey and download the app (as an apk-file). The game within was locked by a server to prevent premature play and could only be accessed once the first phase officially started. In the survey, we assessed demographic information (age, gender, how long they had been living in Germany, how long they had been living in the city in which the experiment was conducted), participants' game motivation (how much they were involved in and how they felt about these games in general) and their general waste sorting motivation (how they felt about municipal waste sorting). We also included several controls checking language proficiency and conscientiousness in answering the questions. To ensure absolute anonymity in the datasets when linking the game data to the survey entries, each app showed a unique code that participants had to report in each respective survey. For this phase, we set a 48-hour timeframe followed by a pause of 24 hours that allowed for troubleshooting.

P2: In the second phase, we sent the next set of instructions as well as another survey link via email. We instructed the participants on the four game-based treatments to open the application and to play it through to the end and then complete the survey. In contrast, we told the control group with the non-interactive materials to attentively read through the teaching materials provided through the link for 25 minutes (this time was derived from the average playtime of the experimental version of the game during the pre-tests) and to then complete the survey. The last part of the survey was the same for all treatments: we measured the perceived usability of the application—or the materials in the case of the non-game material treatment—with the system usability scale (Brooke 1996) as well as self-stated perceived growth in competency and growth in motivation. To adapt the 30 minutes of focused attention to the survey and training, we gave participants a four-day timeframe—including a weekend—to finish the

task. We scheduled the final sessions 10-12 days after the deadline for the second phase, depending on the day of the assigned session.

P3: The experiment took place in a laboratory in 19 experimental sessions. Each participant was seated in a cabin where they were guided through the first part of the experiment with the final survey. We first asked participants about their perceived growth in competency and growth in motivation, and there was a final control question on any prior knowledge about the project. Next, we tested the learning outcome in three different performance measures. First, the participants completed a multiple-choice test in which they had to match all 108 trained waste items. Second, we asked all participants to take their phones and start the game application, where they had to sort all 108 items in a special version of the game. Here, each item appeared only once in one big game wave without the two additional design elements. Third, we called the participants into a separate room, where we asked them to sort a selection of real-life waste items. The design of the experimental procedure was pre-tested with seven participants.

Design Elaborations on the General Game

The experiment as described in this manuscript is based on a reduced version of the serious game we built. As a complete game, it features a full set of additional game mechanics. It can be downloaded here (Apple: https://apps.apple.com/de/app/die-m%C3%BCll-ag/id1046221391, Android: https://play.google.com/store/apps/details?id=com.bunnyandgnome.mullag, Windows -Ger: https://www.microsoft.com/de-de/p/die-mull-ag/9nblggh6bvnv, Windows-Eng: https://www.microsoft.com/en-us/p/trash-monsters/9nblggh6bvnv). As it might be interesting to readers to know which design decisions we made to inspire long-term interactions with the game, the following sections give further insights into some of the mechanics that were excluded from the experimental version of the game.

General Setting

We designed the overall setting as a cartoon world on a waste sorting planet that serves as the main hub of the game. This world represents a metaphorical holistic view of the waste management process. The waste planet is inhabited by monsters that represent the different waste recycling processes and they all live and work together on the planet as it is their job to take care of the city planets' waste. Their homes can be visited by the player, which we designed to achieve higher emotional involvement and commitment to the topic through social interactions with the monsters. The planet overview screen connects the games' different locations. These locations are i) the waste sorting facility, where the core gameplay takes place, ii) the monsters' living spaces, where players accept quests and different minigames can be played, and iii) the info centre, where players get information on the current state of the game (pollution, sorting correctness and unlocked quests). Adjacent to the waste planet is another smaller planet that represents the respective waste supplier (in the current version, the waste system of Karlsruhe city). As each region in Germany has autonomy in its choice of waste management system, the game is designed to switch systems according to the city planet to which it is connected.

Story

We designed each monster with a different type of personality that is linked to the type of waste they represent. For example, the monster representing the residual waste bin is a dragon that burns incoming residual waste. With this, we wanted to make it transparent what currently happens to objects that are thrown into the residual waste bin. We also made its personality cynical and grumpy as it understands the necessity of its job within the waste management system but at the same time hates the inevitable waste of resources that comes with its assigned job. Players can visit each monster in their home and explore their personalities through conversation. A questline is connected to each monster, resulting in the unlocking of mini quests or additional areas within the game. The questline and story progress are regulated through the game waves and new content is unlocked after each wave. Apart from the

consecutive quest structure, an additional story point is introduced in the middle of the game: the volcano starts to be active again. After a few warning earthquakes, it erupts toward the end of the game. Instead of emitting lava, it erupts into a fountain of waste that had been accumulating within the core of the planet over many years. This initiates the final waves of the game, where players have to sort double and triple amounts of waste at maximum speed to get on top of the emergency. Related to the main story, there is also an underlying mystery surrounding the planet and its history that curious and meticulous players can explore.

Unlockable Content (Minigames, Accessories, Mystery)

We embedded three minigames into different locations that impart additional waste sorting information to the players. The first minigame represents the inner workings of a composting plant and is inspired by the mobile game Fruit Ninja (Halfbrick Studios pty. ltd. 2010). The second minigame represents the process of glass separation at the glass container and the third the operating principles of a battery recycling process. Every time players successfully complete a minigame, they are awarded one of nine accessories that they can present to any monster on the planet as wearables. There are also three upgrades that players can unlock to enhance the core gameplay: a lever that is unlocked in two parts and allows players to either slow down or speed up the conveyor belt, as well as a second conveyor belt that transports waste that would otherwise have fallen off the first one back across the screen. We included these items to give players the control to readjust the difficulty of the main game, to allow them to explore "the outer edges of their competency" (Gee 2003) or take away some pressure from the core gameplay. Finally, the game features a guide where players learn how to recycle paper by themselves and there is a dog that represents bulky waste management and can be trained to pick up bulky waste that occasionally blocks the main game.

Exclusion of Game Design Elements

We designed the game as single player due to limitations in development resources. Thus, game incentives that build upon multiplayer interactions such as leaderboards were not included. Also, while leaderboards can be a strong incentive for certain player types, we

designed the game with a strong focus on collaboration and shared responsibility. For this, we particularly focused our efforts on the design of the relationship that players develop with the monsters. We reasoned that especially young players might be deterred from irresponsibly missorting waste items in real life if they feel an empathic connection to the monsters they encounter within the game.

Apart from the adventure mode, where the core gameplay is embedded into a narrative structure, the app also offers an endless mode of the core gameplay, where the waste items are randomly dropped and players can train and test their sorting skills outside the story mode. This mode would be suitable for the inclusion of competitive elements like leaderboards, which is planned for, if further development of the game becomes possible.

However, badges can particularly be easily perceived as a low-cost/effort playing motivator that could even lead to the opposite of the desired effect (Hamari 2017). Thus, from a design perspective, we believe that such game design elements should only be included in a game or gameful application if there is neither the time nor the budget to design a fully realized experience.

Non-Game Materials

Four Bins - Examples

Residual waste		Recycleables	Biowaste*	Paper | Cardboard
Ring binder, plastic	Nylon tights	**Wood, untreated, like:**	Balcony plants	**Recycled paper like:**
Ashes - packed	Camera lenses	Wooden boards, Fruit crate	Banana peels	Ring binder - cardboard
Baking/grease-proof paper	Paper, very soiled		Food waste bin liners	Envelopes, with and
Eye glasses, broken	or imbued	**Recyclables, like:**	Bread	without viewing panel
Sanitary pads	Paper towels & tissues,	CDs	Eggshells	Brochures
Photographic slides	soiled	Bucket - emptied	Fish offal	Books
Floppy disks	Parchment Paper	Plastic crockery	Offal	Egg boxes
Extractor fan filter	Sticky plaster	Bottles, canisters	Vegetable peel	Wrapping paper,
Bicycle saddle	Paintbrush	Plastic film, plastic bags	Hair	uncoated
Pelts / Skins	Porcelain	Childrens toys	Burlap	Notebooks
Binoculars	Dolls	Mixing bowl	Coffee grounds	Cardboard boxes
Heat-proof glass	Cleaning rags	Styrofoam (sundries	Cheese residues	Catalogues
Lighter, empty	Eraser	in transparent bags)	Bones	Magazines
Photographic film	Razor blades		Dead parts of plants	Paper - loose
Felt-tip markers, dried out	Roller skates	**Metals, like:**	Nutshells	Papertowels - if
Photographs	Soot - packed	Antenna	Fruit waste	only slightly moist
Fountain pen, empty	Shoes - unusable	Baking Dish, metal	Orange peel	Paper packaging
Doormat	Napkins - used	Sheet metal	Seeds	Cardboard
Garden hose	Skateboard	Cans - emptied	Cut flowers	Posters
Gift wrap,	Mirror glass	Electric cable	Left-overs, raw	Brochures
coated	Syringes,	Crown cap	(no soups and sauces)	Writing paper
Light bulbs	safely packed	Brass keys	Tea bags	Packaging from paper,
Rubber materials	Vacuum cleaner bag	Pans, pots	Potted plants	cardboard, carton
Suspenders	Tampons	Tool parts	Rotting food,	Advertisements - printed
Inline skates	Wallpaper leftovers		wihout packaging	Journals
Cassettes (audio | video)	Electric torch,	**Aluminium, like:**	Sausage and processed	Newspapers
Chewing gum	without batteries	Cling film	meat leftovers	
Sweepings	Pieces of carpet,	Yoghurt pot lids	Lemon peel	**Recycled paper can also be**
Ceramics, no	chopped up	Chocolate foil		**donated to the wastepaper**
sanitary ceramics	Thermal paper	Tubes, no contaminants,	**Biowaste that does**	**collection.**
Candle stubs	Thermos flask	emptied	**not emerge from**	
Sticky tape	Animal bedding		**households has to be**	**Tipps:** Remove the tape
Sticky labels	Clocks - no batteries	**Composite packaging**	**disposed of**	from your shipping boxes,
Carbon paper	Wound dressing	**like:**	**commercially.**	to fold them in a space-saving
Ball pen refill	Packaging, strongly	Blister packs		manner. Carton packaging can
Pleather	soiled	Milk carton - emptied		equally be folded flatly.
Cuddly toys	Hot-water bottle - gummi	Paper bag with		Avoid unnecessary paper
Leatherbags, -belts	Absorbent cotton	synthetic padding		waste e.g. by using an
Left-over linoleum	Wicker basket	Juice cartons - emptied	*if not available:	advertising ban sticker
Airbed	Diapers	Vacuum packaging	self-composting	on your mailbox.
Rags	Cigarette ends			
Crayons, solvent-free	Ignition plugs	**Packaging, scraped**		
Left-over bits of food		**clean, from:**		
		Wood, plastic, metal		

Some waste types are collected via alternative waste disposal facilities like recycled glass-, used textiles-, organic waste containers, composting facilities, recycling stations, bulk waste collections as well as contaminant collection facilities.

Electrical and electronic appliances up to 50 centimeters edge length can be dropped free of charge at all recycling stations.

Large appliances can also be dropped free of charge at all recycling stations. Large electrical appliances (ovens, stoves, cooling- and freezing appliances, dryers, washing machines) will be picked up on demand. Small equipment can be placed adjacently free of charge.

Figure 1. Flyer on General Waste Sorting in Karlsruhe, translated

Figure 3. Flyer on Bins and Representative Waste Items
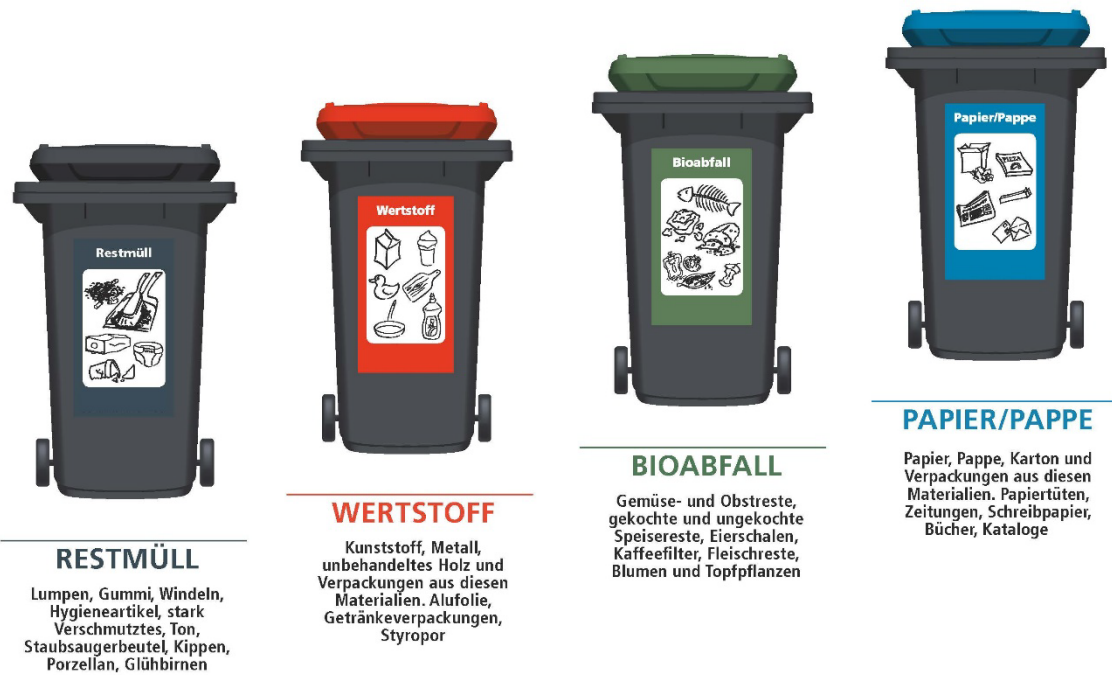
RESTMÜLL
Lumpen, Gummi, Windeln, Hygieneartikel, stark Verschmutztes, Ton, Staubsaugerbeutel, Kippen, Porzellan, Glühbirnen

WERTSTOFF
Kunststoff, Metall, unbehandeltes Holz und Verpackungen aus diesen Materialien. Alufolie, Getränkeverpackungen, Styropor

BIOABFALL
Gemüse- und Obstreste, gekochte und ungekochte Speisereste, Eierschalen, Kaffeefilter, Fleischreste, Blumen und Topfpflanzen

PAPIER/PAPPE
Papier, Pappe, Karton und Verpackungen aus diesen Materialien. Papiertüten, Zeitungen, Schreibpapier, Bücher, Kataloge

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RESTMÜLL

WAS?
Staub, Kehricht, Windeln, Asche (kalt verpackt), Keramik, Porzellan, stark verschmutzte Materialien wie Hygienepapier, Glühbirnen, zerschnittene Teppichreste, Tapetenreste, nicht tragfähige Kleidung und Schuhe

WOHIN?
In die Restmülltonne oder Anlieferung an der Wertstoffstation.
Für vorübergehend anfallende Spitzenmengen können Sie im Handel spezielle Abfallsäcke erwerben.

ORGANISCHE ABFÄLLE

WAS?
Küchenabfälle wie Obst- und Gemüseabfälle, Teebeutel, Kaffeefilter, Eierschalen, rohe und gekochte Speisereste, verwelkte Blumen
Grünabfälle wie Laub, Rasen und Baumschnitt, verwelkte Pflanzen

WOHIN?
Küchenabfälle in die Biotonne oder selbst kompostieren.
Grünabfälle zum Grünabfallcontainer, zu den Wertstoffstationen und zu den Kompostierungsanlagen.

GLAS

WAS?
Hohlglas wie Einweggläschen, Marmeladen- und Gastgläser
Flachglas Fensterglas ohne Rahmen, Aquarienglas, Glasregalböden

WOHIN?
Hohlglas getrennt nach Farben in die Altglascontainer. Aber: besser Pfandflaschen benutzen.
Flachglas nur zu den Wertstoffstationen.

WERTSTOFFE UND PAPIER

WAS?
Metall, Kunststoff, Styropor, unbehandeltes Holz und Verpackungen aus diesen Materialien
Papier, Pappe, Kartons und Verpackungen aus diesen Materialien

WOHIN?
Wertstofftonne für Metall, unbehandeltes Holz und Kunststoff.
Papiertonne für Papier, Pappe und Kartonlagen. Wertstoffe vorsortiert zu den Wertstoffstationen.
Papier zur Straßensammlung.

SCHADSTOFFE

WAS?
Energiesparlampen, Leuchtstoffröhren, Farbe, Kleber, Lacke, Putzmittel, Kosmetika, Fette, Öle, Lösemittel, sonstige Chemikalien, Medikamente, Pflanzen- und Schädlingsbekämpfungsmittel, Batterien

WOHIN?
Mobile Schadstoffsammlung oder Schadstoffannahmestellen.
Energiesparlampen auch zu allen Wertstoffstationen.
Haushaltsbatterien zurück zum Handel oder zu den Batteriesammelbehältern im Stadtgebiet. Autobatterien zum Händler (Pfand) oder zur Schadstoffsammlung.

TEXTILIEN

WAS?
Kleidungsstücke, die noch gut erhalten sind
Schuhe paarweise zusammengebunden

WOHIN?
Alttextilcontainer bei vielen Altglascontainern und auf den Wertstoffstationen oder: Karitative Organisationen, Tausch- und Verschenkmarkt, Second-Hand-Läden, Flohmärkte.
Nicht mehr Tragbares in die Restmülltonne, Teppiche zum Sperrmüll.

Figure 2. Flyer on Waste Categories

Additional Literature Overviews

Table 1. Literature Comparison between Errorful (EF) and Errorless (EL) Learning

Authors	Context	Subjects	Conclusion
Baddeley and Wilson (1994)	Clinical	16 people with brain injuries and memory impairment, and 16 young and older controls each	EL is better than EF
Clare et al. (1999)	Clinical	One participant with Alzheimer's disease	EL is effective and useful for memory problems
Clare and Jones (2008)	Clinical	Six participants with early-stage DAT	EL is effective and useful for memory problems
Donaghey et al. (2010)	Clinical	30 people with an amputated limb, randomly assigned to either the experiment or control group	EL is better than EF
Dunn and Clare (2007)	Clinical	10 people with different conditions	No difference
Evans et al. (2000)	Clinical	Phase 1: 18 people with brain injuries and memory impairment. Phase 2: 16 people with brain injuries and memory impairment. Phase 3: 34 people with brain injuries and memory impairment	Mixed results but overall better performance with EL
Hunkin et al. (1998)	Clinical	Eight people with memory impairment	EL is better than EF
K. Ivancic and Hesketh (2000)	Driving Education	Experiment 1: 44 people in two equal groups Experiment 2: 32 people in two equal groups	EF is better than EL
Johnson (2004)	Learning Strategies	Evidence aggregation of different studies	EF is better than EL
Jones and Eayrs (1992)	Teaching Strategies	Literature synopsis	Inconclusive
Kessels and Haan (2003)	Natural Ageing	18 elderly and 16 young controls	EL is better than EF
Kessels et al. (2007)	Clinical	10 people with Korsakoff Syndrome	No difference
Ohlsson (1996)	Learning Strategies	Tests on the evaluation of own performance errors—more theoretical	Inconclusive
Prather (1971)	Airforce Education	96 people	EF and EL are similarly effective
Page et al. (2006)	Clinical	Experiment 1: 23 people with memory impairment and 20 controls Experiment 2: 20 people with memory impairment	EL is better than EF
Tailby and Haslam (2003)	Clinical	24 people in three groups of eight each with different severity of memory impairment	EL is better than EF

Control and Additional Variables

Table 2. Operationalization of Control and Additional Variables

Controls	English	German	Tested with
Age	"Please tell us your age"	*„Bitte teile uns Dein Alter mit."*	Integer value
Gender	"Which gender do you identify with?"	*„Welchem Geschlecht ordnest Du Dich zu?"*	Male/female/other *Männlich/ Weiblich/ Sonstiges:*

Living in Germany	How long have you been living in Germany? Please answer with number of full years.	*„Wie lange wohnst Du schon in Deutschland? Bitte antworte in ganzen Jahren."*	Integer value
Living in XX City	How long have you been living in XX? Please answer with number of full years.	*„Wie lange wohnst Du schon in XX? (Bitte antworte in ganzen Jahren)"*	Integer value
Game motivation (medium acceptance)	Please tell us about your attitude towards games.	*„Bitte teile uns Deine Einstellung gegenüber Gaming mit."*	(sub-headline)
	I play videogames (computer games, smartphone games, console games, ...) in my free time.	*„Ich spiele in meiner Freizeit Videospiele (Computerspiele, Handygames, Konsolenspiele,...)."*	Likert (five-point): Strongly disagree, rather disagree, neither agree nor disagree, rather agree, strongly agree *Stimme gar nicht zu, stimme eher nicht zu, teils-teils, stimme eher zu, stimme voll und ganz zu*
	I am prejudiced towards grown-ups who play videogames. (r)	*„Ich habe Vorurteile gegenüber erwachsenen Menschen, die Videospiele spielen."(r)*	
	I wish videogames were more accepted in society.	*„Ich wünschte, Videospiele würden eine höhere Akzeptanz in der Gesellschaft genießen."*	
	I think videogames are a waste of time. (r)	*„Ich denke, dass Videospiele eine Form der Zeitverschwendung sind."(r)*	
	Videogames are my hobby.	*„Videospiele sind mein Hobby."*	
	I feel that too much attention is spent on videogames. (r)	*"Ich finde, dass man Videospielen zu viel Aufmerksamkeit schenkt."(r)*	
General waste sorting motivation (general interest in the topic)	What is your attitude towards waste sorting at home? Please answer honestly.	*„Wie ist Deine Einstellung zu Mülltrennung? Bitte antworte ehrlich."*	Likert (five-point) Fully applicable, rather applicable, partly applicable, rather not applicable, not applicable *trifft voll zu, trifft eher zu, teils-teils, trifft eher nicht zu, trifft nicht zu*
	I have never given any thought to waste sorting.	*„Ich habe mir noch nie über Mülltrennung Gedanken gemacht."*	
	Waste sorting at home is very important to me.	*„Mir ist Mülltrennung im Haushalt sehr wichtig."*	
Waste sorting motivation and competency	Please let us know to what extent you agree with the following statements.	*„Bitte teile uns mit, inwiefern Du den folgenden Aussagen zustimmst"*	Likert (five-point) Strongly disagree, rather disagree, neither agree nor disagree, rather agree, strongly agree *Stimme gar nicht zu, stimme eher nicht zu, teils-teils, stimme eher zu, stimme voll und ganz zu*
Waste sorting motivation: last two weeks	Since part 2 of the experiment, have you been more motivated to correctly sort your waste?	*Warst Du seit Teil 2 des Experimentes motivierter, Deinen Müll korrekt zu trennen?*	
Waste sorting motivation: from now on	Since part 2 of the experiment, have you felt more skilled at correctly sort your waste?	*Hast Du Dich seit Teil 2 des Experimentes kompetenter darin gefühlt, Deinen Müll richtig zu trennen?*	
Waste sorting competency: last two weeks	After participating in this experiment, do you feel more motivated to correctly sort your waste from now on?	*Bist Du nach Abschluss dieses Experiments motivierter, ab jetzt Deinen Müll korrekt zu trennen?*	
Waste sorting competency: from now on	After participating in this experiment, do you feel more skilled at correctly sort your waste from now on?	*Fühlst Du Dich nach Abschluss dieses Experiments kompetenter darin, Deinen Müll ab jetzt richtig zu trennen?*	
SUS	See Brooke (1996).	See Brooke (1996)	Likert-based five-point See Brooke (1996)

(r) refers to the questions being reverse-coded

Table 3. Control Variables - Descriptive Statistics

	Mean	Std. Dev.	Min	Max	Scale/Type of Measure
Age	22.72	3.01	17	41	Age in years (integer values)
Living in Germany	20.73	5.90	0	30	Number of years (integer values)
Living in XX City	4.28	5.46	0	28	Number of years (integer values)
Gaming motivation	3.12	.90	1.17	5	Likert five-point (six items, three reverse-coded)
General waste sorting motivation	4.23	.80	1.5	5	Likert five-point (two items)
SUS	78.79	12.93	30	100	SUS score: map answers (Likert five-point) from 0 (lowest) to 4 (highest), add the values of all 10 items and multiply by 2.5

Table 4. Control Variables – Descriptive Statistics per Treatment

	Non-game material		Repeat element		Look-up element		Combined		Core gameplay	
	mean (min/max) / percent for gender	std. dev.	mean (min/max)	std. dev.	mean (min/max)	std. dev.	mean (min/max)	std. dev.	mean (min/max)	std. dev.
Age	23.28 (19/30)	3.28	22.6 (18/41)	3.76	22.42 (17/28)	2.46	23.34 (18/32)	2.83	22.09 (19/30)	2.47
Gender (male)	71.8%		65.2%		75.6%		63.4%		54.5%	
Gender (female)	28.2%		32.6%		24.4%		36.6%		45.4%	
Gender (diverse)			2.2%							
Living in Germany	21.85 (3/30)	5.46	20.22 (2/28)	5.33	21.13 (1/28)	5.48	21.34 (3/28)	5.64	19.30 (0/30)	7.27
Living in XX City	4.08 (0/28)	5.60	4.82 (0/23)	6.13	3.77 (0/22)	4.00	4.46 (0/27)	5.74	4.26 (0/27)	5.77
Gaming motivation	3.25 (1.17/5)	1.05	3.04 (1.17/5)	.89	3.21 (2/4.83)	.80	3.03 (1.33/4.67)	.88	3.07 (1.17/4.67)	.88
General waste sorting motivation	4.13 (1.5/5)	.92	4.23 (2/5)	.74	4.13 (2/5)	.84	4.44 (2.5/5)	.64	4.23 (2/5)	.84
SUS	76.73 (32.5/95)	14.13	78.91 (47.5/95)	11.91	75.44 (45/97.5)	13.86	81.59 (42.5/100)	10.81	81.31 (30/100)	13.13

Additional Analyses

Table 5. Effect of the Game in Comparison with the Non-Game Material Group with Control Variables

	In-Game Performance		Multiple-Choice Test		Real-Life Sorting	
Reference category: Non-game material	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)

	In-Game Performance		Multiple-Choice Test		Real-Life Sorting	
Game (all 4 game treatments	.045 (.016) [.019, .072]	.005**	.090 (.019) [.058, .121]	.000**	.068 (.031) [.018, .119]	.025*
Control Variables						
Age	.000 (.003) [-.005, .005]	.961	-.001 (.003) [-.007, .005]	.714	-.007 (.004) [-.015, .000]	.060
Gender	-.020 (.014) [-.048, .007]	.145	-.017 (.016) [-.049, .015]	.306	-.049 (.027) [-.102, .005]	.073
Living in Germany	.005 (.001) [.002, .007]	.000**	.005 (.002) [.002, .008]	.002*	.003 (.003) [-.002, .009]	.229
Living in XX City	.001 (.001) [-.001, .003]	.341	.002 (.001) [-.001, .004]	.170	.002 (.002) [-.002, .005]	.406
Gaming motivation	.009 (.007) [-.005, .023]	.210	.009 (.008) [-.007, .025]	.290	.010 (.013) [-.016, .036]	.446
General waste sorting motivation	.020 (008) [.004, .035]	.012*	.016 (.009) [-.002, .033]	.085	.027 (.016) [-.005, .059]	.100
SUS	.001 (.000) [-.001, .002]	.064	.001 (.001) [-.000, .002]	.262	.001 (.001) [-.001, .003]	.181
Constant	.426 (.066) [.318, .534]	.000**	.361 (.079) [231, .492]	.000**	.570 (.108) [.392, .748]	.000**
N	213		213		213	
R²	.193		.212		.091	
Adj. R²	.161		.181		.055	

For the treatment groups, we used an alpha-error level of 10% (*p<0.1, ** p<0.01).
For the other controls that did not have directed hypotheses, we set the alpha-error level to 5% (* p<0.05, ** p<0.01).
Male was coded as 0, female as 1 and diverse as 2.

Table 6. Effects of the Design Elements in Comparison with the Non-Game Material Group with Control Variables

	In-Game Performance		Multiple-Choice Test		Real-Life Sorting	
Reference category: Non-game material	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)
Repeat element	.033 (.020) [.001, .066]	.094*	.086 (.023) [.048, .124]	.000**	.073 (.038) [.010, .135]	.056*
Look-up element	.044 (.021) [.009, .078]	.037*	.090 (.023) [.052, .127]	.000**	.072 (.037) [.012, .132]	.050*
Combined	.076 (.019) [.044, .107]	.000**	.117 (.023) [.079, .154]	.000**	.056 (.040) [-.010, .123]	.163
Core gameplay	.029 (.020) [-.004, .062]	.144	.065 (.023) [.027, .104]	.005**	.071 (.035) [.013, .129]	.045*
Control Variables						
Age	-.000 (.002) [-.005, .004]	.841	-.002 (.003) [-.007, .004]	.542	-.007 (.004) [-.015, .001]	.074
Gender	-.019 (.014) [-.046, .008]	.175	-.014 (.016) [-.046, .018]	.389	-.049 (.028) [-.103, .005]	.078
Living in Germany	.004 (.001) [.002, .007]	.000**	.005 (.002) [.002, .008]	.002**	.003 (.003) [-.002, .009]	.239
Living in XX City	.001 (.001) [-.001, .003]	.265	.002 (.001) [-.001, .004]	.140	.002 (.002) [-.002, .005]	.433
Gaming motivation	.009 (.007) [-.005, .023]	.195	.009 (.008) [-.007, .026]	.267	.010 (.013) [-.016, .036]	.461

General waste sorting motivation	.018 (.008) [.003, .033]	.019*	.014 (.009) [-.003, .032]	.114	.028 (.017) [-.005, .060]	.095
SUS	.001 (.000) [-.000, .002]	.064	.001 (.001) [-.000, .002]	.255	.001 (.001) [-.001, .003]	.170
Constant	.449 (067) [.318, .580]	.000**	.382 (.079) [.228, .536]	.000**	.561 (108) [.347, .774]	.000**
N		213		213		213
R²		.219		.233		.092
Adj. R²		.176		.191		.042

For the treatment groups, we used an alpha-error level of 10% (*p<0.1, ** p<0.01).
For the other controls that did not have directed hypotheses, we set the alpha-error level to 5% (* p<0.05, ** p<0.01).

Table 7. Effects of the Design Elements in Comparison with the Core Gameplay

	In-Game Performance		**Multiple-Choice Test**		**Real-Life Sorting**	
Reference category: Core gameplay	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)	coef. (bootstr. std. error) [conf. interval]	p (two-tailed)
Repeat element	.004 (.019) [-.027, .035]	.831	.021 (.022) [-.015, .056]	.337	.002 (.033) [-.052, .056]	.958
Look-up element	.015 (.021) [-.019, .049]	.470	.024 (.021) [-.011, .059]	.256	.001 (.033) [-.023, .055]	.978
Combined	.047 (.019) [.016, .077]	.012*	.052 (.022) [.017, .086]	.015*	-.015 (.036) [-.073, .044]	.681
Non-game material	-.029 (.020) [-.062, .004]	.144	-.065 (.023) [-.104, -.027]	.005*	-.071 (.035) [-.129, -.013]	.045*
Control Variables						
Age	-.000 (.002) [-.005, .004]	.841	-.002 (.003) [-.007, .004]	.542	-.007 (.004) [-.015, .001]	.074
Gender	-.019 (.014) [-.046, .008]	.175	-.014 (.016) [-.046, .018]	.389	-.049 (.028) [-.103, .005]	.078
Living in Germany	.004 (.001) [.002, .007]	.000**	.005 (.002) [.002, .008]	.002**	.003 (.003) [.002, .009]	.239
Living in XX City	.001 (.001) [-.001, .003]	.265	.002 (.001) [-.001, .004]	.140	.002 (.002) [-.002, .005]	.433
Gaming motivation	.009 (.007) [-.005, .023]	.195	.009 (.008) [-.007, .026]	.267	.010 (.013) [-.016, .036]	.461
General waste sorting motivation	.018 (.008) [.003, .033]	.019*	.014 (.009) [-.003, .032]	.114	.028 (.017) [-.005, .060]	.095
SUS	.001 (.000) [.000, .002]	.064	.001 (.001) [-.000, .002]	.255	.001 (.001) [-.001, .003]	.170
Constant	.478 (.065) [.350, .606]	.000**	.447 (.078) [.294, .601]	.000**	.632 (.107) [.421, .842]	.000**
N		213		213		213
R²		.219		.233		.092
Adj. R²		.176		.191		.042

For the treatment groups, we used an alpha-error level of 10% (*p<0.1, ** p<0.01).
For the other controls that did not have directed hypotheses, we set the alpha-error level to 5% (* p<0.05, ** p<0.01).