Gamifying a Simulation: Do a Game Goal, Choice, Points, and Praise Enhance Learning? – Supplementary Material

1. Constructs measured by questionnaires during the experiment

Construct	When measured	Questions	Scale
Self-assessed prior knowledge $(\alpha = .68^a)$	prior to the experiment	• Q1a: My relatives (or I personally) brew beer. • Q1b: I have taken part in an excursion to a brewery. • Q1c: We learnt about beer brewing in school. • Q1d: I know what *Saccharomyces cerevisiae* is. • Q1e: I know how *Lactobacillus* can influence beer. • Q1f: I know why malt is added to beer before yeast.	dichotomous: agree – not agree
		• Q2: Please write down whether you have ever tried to learn about the topic of beer brewing. If so, when and where?	open-ended
		• Q3: Should you be asked to explain why and when alcohol is created during the beer brewing process, would you consider yourself to be:	4-point ordinal item (*1) I don't know, so far I have had no interest in this topic; 2) beginner, I know something about the topic; 3) intermediate; 4) advanced, I know quite a lot about the topic.*)
		• Q4: Can you explain why a morning headache can be worse when you drink non-alcoholic beer rather than alcoholic beer the evening before?	6-point Likert item (*1 - definitely yes; 6 - definitely no*)
		• Q5: How often do you discuss the topic of beer brewing with your friends or family?	6-point Likert item (*1 - always; 6 – never*)
		• Q6 – 8: Check to indicate your knowledge of beer	6-point Likert item (*1 - very good;*

		brewing [Q6] / wine-making [Q7] / whiskey production [Q8].	*6 - very weak)*
Self-assessed knowledge of mathematics	prior to the experiment	• Check one of the following to indicate your knowledge of mathematics.	6-point Likert item ((*1 - very good; 6 - very weak*)
Self-assessed ICT skills	prior to the experiment	• Check one of the following to indicate your knowledge of ICT.	6-point Likert item (*1 - very good; 6 - very weak*)
Frequency of playing live action experiential /simulation games	prior to the experiment	• How often do you play experiential and/or simulation games or tabletop role-playing games (e.g. LARPs, simulations of medieval battles, outdoor puzzle hunts, AD&D, etc.)?	5-point ordinal item (*1 – never or I don't know what these terms mean; 2) once or twice so far; 3) approx. once a year; 4) more than once a year, but less than once a month; 5) at least once a month on average.*)
Self-assessed ability of acquiring mental models	prior to the experiment	• Imagine you will be examined on the history of shipping traffic in the 19th century. A week before the exam, the examiner proposes you that you can learn just one of the following two things: a) the names of British steamboats from the second half of the 19th century, including their displacement and their propeller type, or b) how these steamboats' propellers work. There are over 60 of steamboats and five functionally-distinct types of propellers. What would you prefer to learn?	7-point Likert item (*1 - I strongly prefer the names of the steamboats, including their displacement and propeller type; 7 - I strongly prefer to learn how the propellers work*)
Energy	prior to the experiment	• How alert do you feel this morning? • How do you feel overall right now?	two 7-point Likert items (*1 – very well; 7 – very bad*)
Prior attitude	prior to the experiment	• My thoughts pertaining to this experiment are:	7-point Likert item (*1 – very positive; 7 – very negative*)
Initial anxiety (three questions from the Questionnaire on Current Motivation; Rheinberg et al., 2001) (α = .81)	1st in situ; after tutorial	• When I think about the task, I feel somewhat concerned. • I am afraid I will make a fool of myself. • I think I won't do well at the task.	three 7-point Likert items (*1 – don't agree at all; 7 – I completely agree*)
Graphing skills (shortened version; McKenzie & Padilla, 1986) (α = .76)	in the delayed testing session (a month after the intervention)	9 items, see McKenzie & Padilla (1986)	nine multiple choice items

Initial interest (five questions from the Questionnaire on Current Motivation; Rheinberg et al., 2001) ($\alpha = .82$)	1st in situ; after tutorial	• Today's topic seems very interesting to me. • I am eager to see how I will perform on today's task. • I'm really going to try as hard as I can on this task. • While doing this task I will enjoy discovering how to brew beer. • I would work on this task even in my free time (if I have the instructional animation).	five 7-point Likert items (*1 – don't agree at all*; *7 – I completely agree*)
Generalized positive affect (i.e., the positive scale of PANAS; Watson et al., 1988) ($\alpha = .87, .88$)	3rd and 4th in situ; after the error and the task-solving parts	10 items, see Watson et al. (1988) with the following initial instruction: • Mark to what extent you experience these feelings at this moment: [the list of 10 feelings; e.g., interested, active, alert, excited].	ten 5-point Likert items (*1 – very slightly or not at all*; *5 – extremely*)
Flow (Flow Short Scale; Rheinberg et al., 2003) ($\alpha = .93, .90$)	3rd and 4th in situ; after the error and the task-solving parts	10 items, see Rheinberg et al. (2003) e.g. • I do not notice time passing. • I feel I have everything under control. • I am completely lost in thought.	ten 7- point Likert items (*1 – definitely no*; *7 – definitely yes*)
Learning involvement (inspired by Schraw et al., 1995; Isen & Reeve, 2005) ($\alpha = .86, .88, .81$)	2nd – 4th in situ; after the linear, the error and the task-solving parts	• So far, I have enjoyed brewing beer. • I always knew what to do next. • I always knew how to complete the assigned tasks. • I'm tired. • I'm looking forward to the next part [the 4th in situ administration: I'd like to continue in brewing beer] • I focused on brewing beer. • I think I am doing well so far. • I was careful and conscientious when completing the tasks.	eight 7-point Likert items (*1 – definitely no*; *7 – definitely yes*)
Enjoyment	post hoc	• I enjoyed doing this activity • I would describe this activity as very interesting	two 6-point Likert items (*1 – very much*; *6 – very little*); reverse coded
Perceived difficulty ($\alpha = .70$)	2nd – 4th in situ, post hoc	• The difficulty of the simulation [4th in situ administration: task-solving] meets my expectations.	four 7-point Likert items (*1 – very easy*; *7 – very difficult*)
Perceived learning	post hoc	• How much do you know about brewing beer? • Do you think that you have learnt something about brewing beer?	two 6-point Likert items (*1 – very much*; *6 – very little*); reverse coded

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Negative affect (i.e., the negative scale of PANAS; Watson et al., 1988) (α = .84, .88)	3rd and 4th in situ; after the error and the task-solving parts	10 items, see Watson et al. (1988) with the following initial instruction: • Mark to what extent you experience these feelings at this moment: [the list of 10 feelings; e.g. irritable, distressed, upset].	ten 5-point Likert items (*1 – very slightly or not at all*; *5 – extremely*)
Manipulation check	2nd – 3rd in situ	• For you personally, would it be better if the grandpa praised you:	5-point Likert item (*1 – much less often; 5 – much more often*)
		• For you personally, how important was it that the grandpa awarded you points? (rating importance and valence)	two 7-point Likert items (importance: *1 - very little; 7 – very much;* valence: *1 – very negative; 7 – very positive*)
	4th in situ	• For you personally, how important was it that money was part of the game? (rating importance and valence)	two 7-point Likert items (importance: *1 - very little; 7 – very much;* valence: *1 – very negative; 7 – very positive*)
		• For you personally, how important was it that you had to achieve a game goal? (rating importance and valence)	two 7-point Likert items (importance: *1 - very little; 7 – very much;* valence: *1 – very negative; 7 – very positive*)

[a]To compute α, scores from six yes/no questions (Q1*x*) and the open-ended question (Q2) were tallied and the sum was used as one variable in the calculation of α (along with the other six variables Q3 – Q8).

2. Knowledge tests – question examples:

Retention, e.g.:

- Write down names of the four main phases of beer brewing in the correct order, as you learned today.

- In what phase or phases of beer brewing are enzymes present during the whole phase?

- Please, describe how temperature is being changed during the whole process.

- Please explain what happens during the fermentation phase and what main products are created during this phase. Imagine you are writing a short encyclopedia entry for beginners. (open-ended)

Transfer, e.g.:

- Why does the chance that the product will spoil increase, if we cannot manage a stable temperature during the whole fermentation phase? **Explain in detail.**

- We got rid of bacteria during the boiling phase. However, after the conditioning, the product still contains acetone (which is a product of bacteria). When and how could acetone have got into the beer? Write down **every possibility** you can imagine.

- "How would you adjust the lager tank so that it can be used for fermentation? Write down **all possibilities** you can think of and **explain** why these changes would be needed." [emphasis always as in the original]

Note: emphasis in the original.

For retention, α was .66 for the immediate test and .73 for the delayed test. For transfer, α were .80 and .63 for the immediate tests and .82 and .75 for the delayed tests.

References

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