Preliminary Development and Evaluation of the Mini Player Experience Inventory (mPXI)

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ABSTRACT

Measuring player experience (PX) is key in most game user research. Recently, the Player Experience Inventory (PXI) was presented, a validated 30-item survey instrument using a 7-point Likert scale. The issue with this instrument is that with 30 items it is too long for research studies for which PX is one of the measures. We present in this work-in-progress paper the mPXI or the mini Player Experience Inventory, a 10-item survey instrument. We evaluated the mPXI with an educational game used in engineering education (n = 169). While further evaluation of the mPXI is needed, the current results show promise for using a shortened version of the original PXI.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**; *HCI theory, concepts and models*; *Empirical studies in HCI*.

KEYWORDS

Player Experience; Survey; Game User Research; Scale Development

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1 INTRODUCTION

While many methods and techniques exist to measure player experiences (e.g., biometrics [28], game data [18], ethnography [9] etc.), player's self-reports continue to be popular in game user research (GUR) [12, 17], due to the ease of deploying and analyzing such instruments. However, Player Experience (PX), defined as "the individual, personal experience held by the player during and immediately after the playing of the game" [30] is an elusive concept, and many survey instruments have been developed to capture this (e.g., [4, 10, 15, 16, 26]). The most recent effort is the Player Experience Inventory (PXI) [3]. Although this instrument is theoretically grounded and has practical value for improving games, the issue is that with 30 items it is still relatively long, especially for research studies for which PX is one of the measures. In a sense, the GUR community is still in search of the equivalent of the System Usability Scale (SUS) [11], a quick and easy to use 10-item instrument that measures user's subjective rating of a product's usability and that has proven to be a highly robust and versatile tool for usability professionals [5]. With this in mind, in this paper we present the preliminary development and evaluation of the mini Player Experience Inventory (mPXI), a 10-item version of the PXI.

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2 PLAYER EXPERIENCE INVENTORY

The Player Experience Inventory (PXI) is a 30-item 7-point Likert scale survey instrument, which has been rigorously developed and evaluated [3]. The motivation for its development is that most current surveys focus on measuring psychological experiences, and there is a need for an instrument that allows "researchers to understand how lower-level game design choices...are perceived by players, and how these contribute to higher-order psychological experiences" (p. 2). Using Means-End Theory [22, 23] as a basis, which describes how product attributes lead to consequences on different levels of experience, the PXI distinguishes player experience at both the level of *Functional Consequences* (FC) and *Psychosocial Consequences* (PC). FC concern the "immediate, tangible consequences experiences as a direct result of game design choices"; PC the "emotional experiences, as a second-order response to game design choices." Both FC and PC are measured by five constructs (e.g., Meaning, Challenge, etc., see Table 1), which each consist of three 7-point Likert items. For more detail, we refer to the article [3].

In this paper, we examine if the 10-item version of the PXI (i.e., mPXI) supports the theoretical distinction into FC and PC and how it performs as a single measure of PX.

3 METHODS

3.1 mPXI

For developing the mPXI, we could not make use of the correlation matrix presented in [3] and instead relied on a critical review of the 30 items to select one item from each construct, which reduced the number of items to 10. Table 1 presents the selected items. The mPXI was integrated into a post-survey, which also included an item measuring *Satisfaction*: "Rate your overall satisfaction with the <game> on a scale from 1 to 10."

Table 1: The Mini Player Experience Inventory with descriptive statistics and exploratory factor analysis results.

Item	Statement	Construct	Subscale	Rating	1-Factor	2-Factor	
				Mdn (*IQR*)	PX	PC	FC
1	Playing the game was meaningful to me.	Meaning	PC	5 (4–6)	.72		.69
2	I felt capable while playing the game.	Mastery	PC	5 (5–6)	.71		.71
3	I was no longer aware of my surroundings while I was playing.[a]	Immersion	PC	4 (2–5)	—	.50	
4	I felt a sense of freedom about how I wanted to play this game.	Autonomy	PC	5 (4–6)	.58	.78	
5	I felt eager to discover how the game continued.	Curiosity	PC	5 (4–6)	.70	.53	
6	I thought the game was easy to control.	Ease of Control	FC	5 (4–6)	.67		.49
7	The game was challenging but not too challenging.	Challenge	FC	5 (4–6)	.47	—	—
8	The game gave clear feedback on my progress towards the goals.	Progress Feedback	FC	5 (4–6)	.66		.69
9	I enjoyed the way the game was styled.	Audiovisual Appeal	FC	5 (4–6)	.77		.69
10	The goals of the game were clear to me.	Goals and Rules	FC	6 (5–6)	.71		.84

PX = Player Experience; PC = Psychosocial Consequences; FC = Functional Consequences.
[a] Based on the presented results, we recommend replacing this with "I was fully focused on the game."

3.2 Study Context

The mPXI was included in a post-survey that evaluated the use of an educational 3D game called *GeoExplorer*, which targets University students in civil/geotechnical engineering to provide them with opportunities to get experience with various field field testing techniques [2, 7, 8].[1] In this version of GeoExplorer, students played 2–4 exercises where they have to conduct a Cone Penetration Test (CPT), a common in-situ method to determine the geotechnical engineering properties of soils and delineating soil stratigraphy. In a nutshell, for each exercise players have to drive a CPT truck to the desired CPT location, conduct the CPT, and analyze the resulting data while communicating with their manager. The game is implemented as part of a module on CPT in courses that provide an introduction to geotechnical engineering. Due to COVID-19, all students completed the game at their own convenience from home.

3.3 Participants

A total of 169 students participated with the post-survey across five institutions: California State University Fullerton (*n* = 43), Jackson State University (*n* = 11), Manhattan College (*n* = 38), New York University (*n* = 23), and Rensselaer Polytechnic Institute (*n* = 54). The average age was 21.12 years old (*SD* = 2.54). Participants self-identified as a man (64%), woman (32%), or preferred not to answer (4%). While playing GeoExplorer was required as part of the curriculum, participation in this research was voluntary and we obtained informed consent in advance from each student. Two students did not fill out the mPXI and 11 others were not able to play the game and relied on an interactive video.We removed these participants for our analysis, resulting in a dataset of 156 participants.

3.4 Data Analysis

We follow similar analysis steps as presented in the development of the PXI, but make use of R (with the packages `lavaan`, `mediation`, `psych`, and `QuantPsych`) and opted for different methods that have been recommended in the literature for Likert/ordinal scale data. First, we performed an exploratory factor analysis (EFA), which is a recommended practice if a validated scale is changed [29]. Here, we chose using weighted least squares (WLS) as factoring solution and polychoric correlations to account for the ordinal nature of the data and oblimin as rotation method as we anticipate factors to correlate [6, 21]. Second, using the same data, we then ran a confirmatory factor analysis (CFA) using diagonally weighted least squares (DWLS) and polychoric correlations. Although it is suggested that for new scale development it is best to first conduct EFA and then conduct CFA on a new data set instead of using CFA on the same data set [19, 20], in our case this was justified as we have modified the original PXI, warranting EFA, but also aimed to verify the theoretical model as originally proposed with CFA [13]. For the model comparison, we report the most important fit indices: χ^2/df, CFI, TLI, RMSEA with 90% CI, and SRMR [14, 25]. The last step concerns the evaluation of the theoretical model. Here, we used linear regression models with as dependent variable Satisfaction (see 3.1) as opposed to Game Enjoyment.

4 RESULTS

4.1 Descriptive Statistics

The ratings on the mPXI are more or less the same for seven out of ten items (see Table 1). Students stated they "somewhat agree" with the statements (*Mdn* = 5, *IQR* = 4–6). On Item #3, which measures Immersion, we see far less agreement (*Mdn* = 4, *IQR* = 2–5), and on Item #2 (*Mdn* = 5, *IQR* = 5–6) and especially Item #10 (*Mdn* = 6, *IQR* = 5–6) we see more agreement. Overall, we find somewhat positive ratings for PX (*M* = 4.75, *SD* = 1.04), PC (*M* = 4.58, *SD* = 1.08), and FC (*M* = 4.92, *SD* = 1.16). On overall satisfaction, on average the students rated the game 7.50 out of ten (*SD* = 1.84).

4.2 Exploratory Factor Analysis

4.2.1 Reliability. We calculated the Cronbach's alpha for PX (α = .88, CI[.86, .91]), PC (α = .78, CI[.72, .83]), and FC (α = .84, CI[.80,

[1] A video of the game: https://youtu.be/nkYskG52ewM

Table 2: Confirmatory factor analysis results on fit indices.

	χ^2/df	CFI	TLI	RMSEA[a]	SRMR
1-factor w/o cov	4.39	.981	.976	.148 [.125–.172]	.079
2-factor w/o cov	3.72	.986	.981	.132 [.108–.157]	.074
1-factor	1.75	.996	.995	.070 [.038–.099]	.055
2-factor	1.80	.996	.994	.072 [.040–.102]	.055
1-factor w/o #3	1.21	.999	.999	.037 [0–.078]	.039
2-factor w/o #3	1.25	.999	.999	.041 [0–.082]	.039

[a] with 90% confidence interval (CI).

.88]). All values fall almost in the recommended range of .80–.90 to demonstrate internal consistency. For both PX and PC it is suggested the scale would improve by removing Item #3 (α = .90 and α = .83, respectively). Removal of Item #7 would keep the reliability the same for PX and FC. For all other items the reliability would lower if removed for PX, PC, and FC.

4.2.2 Factors. A Kaiser-Meyer-Olkin index of .871 and a significant Bartlett's test of sphericity (χ^2 (45) = 801, p < .001) show that sampling adequacy was considered good. Scree plot and eigenvector analysis suggest a 1-factor or 2-factor solution. With a 1-factor solution all items load high (> .40) and uniquely, except for Item #3. The 2-factor solution shows that Items #3–5 load high on one factor (i.e., PC), all other items on the other (i.e., FC). Item #7 is here in contention. It was just below the cut-off (.34) for the FC factor. Results are displayed in Table 1. The 1-factor solution explains 41% of the variance, the 2-factor 48%.

4.3 Confirmatory Factor Analysis

4.3.1 Covariances. For the CFA, we set out to compare the default 1-factor with the 2-factor model in addition to the outcomes of the EFA, which suggest that both Item #3 and #7 may not be a good fit. All initial results suggest a poor fit on RMSEA only. Modification indices suggest this is a result from not including the covariances between Items #1 and #2, #4 and #5, and #8 and #10. While we acknowledge the issue of overfitting our models in this manner, we continued by including these covariances in some of the models.

4.3.2 Comparison. Table 2 shows the results on the fit indices for the various models we considered. We left out the models that did not include Item #7 as these did not improve the fit indices unlike Item #3. Except for the RMSEA fit index, both the 1-factor as well as 2-factor have an acceptable fit. Except for RMSEA, the fit is otherwise excellent if the covariances are included. If Item #3 is then removed, we find an excellent fit on both the 1-factor (CFI = .999, RMSEA = .037, χ^2/df = 1.21) and 2-factor solution (CFI = .999, RMSEA = .041, χ^2/df = 1.25). We can draw three conclusions from this analysis. First, both the 1-factor as well as the 2-factor are feasible models. Second, the models improve by removing Item #3, confirming our findings from the EFA. Third, there are important inter-item correlations between some of the items.

4.3.3 Validity. For discriminant and convergent validity, we looked at the composite reliability (CR), average variance extracted (AVE), and maximum shared variance (MSV) for the 2-factor solution only. For the 1-factor solution without Item #3, we find a CR of .913 and AVE of .543. For the 2-factor solution without Item #3, we find a CR for PC of .832 and for FC of .851, suggesting good convergent validity. The AVE for PC and FC are .543 and .538, respectively, which is barely higher than the MSV of .537. Thus, the discriminant validity of the 2-factor solution is somewhat questionable.

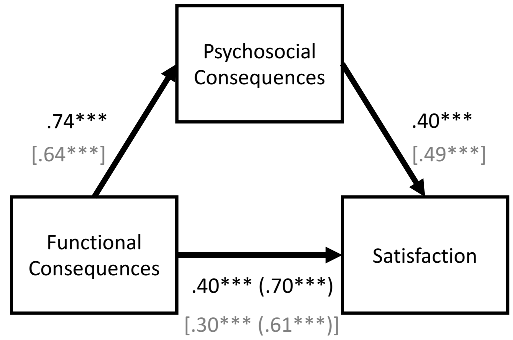

Figure 1: Standardized regression coefficients for the relationship between Functional Consequences and Satisfaction as mediated by Psychosocial Consequences. In brackets the coefficients from the PXI [3]. *** p < 0.001

4.4 Theoretical Model Analysis

Our last step was replicating the theoretical model results from the PXI with the difference of predicting satisfaction instead of enjoyment. As such, we consider the following four hypotheses:

(1) Functional Consequences (FC) positively predict Satisfaction.
(2) FC positively predict Psychosocial Consequences (PC).
(3) PC positively predict Satisfaction.
(4) The effect of FC on Satisfaction is mediated via PC.

Given that we consider the possibility of a 1-factor solution, we added a fifth hypothesis: Player Experience (PX) positively predicts Satisfaction. For this analysis, we removed Item #3.

As for the results, first, FC predicts Satisfaction, b = 0.883, SE = 0.073, p < 0.001, (standardized regression coefficient .700). Second, FC predicts PC, b = 0.603, SE = 0.044, p < 0.001, (standardized regression coefficient .741). Third, PC predicts Satisfaction (while controlling for FC), b = 0.616, SE = 0.125, p < 0.001, (standardized regression coefficient .399). Fourth, when controlling for the effect of the mediator PC on Satisfaction, the effect of FC decreases substantially on Satisfaction, b = 0.510, SE = 0.102, p < 0.001, (standardized regression coefficient .404). Using bootstrapping procedures, we find that this indirect effect is significant (p < .001). The bootstrapped unstandardized indirect effect was .374, and the 95% confidence interval ranged from .185 to .590. Thus, we find support for all four hypotheses. As for the effect of PX on Satisfaction (Hypothesis 5), we also find support: b = 1.392, SE = 0.100, p < 0.001, (standardized regression coefficient .749). Figure 1 shows the results from the original study and this work.

5 DISCUSSION

5.1 Key Findings

5.1.1 PX Matters. While this paper is focused on evaluating the mPXI, it also demonstrates the importance of PX in the context of educational games. With a standardized regression coefficient of .75 how students perceived their PX is a strong predictor of their overall satisfaction. Satisfaction encompasses more than enjoyment as it also evaluates students' perceived value from playing the game in the context of their coursework and thus what they learned from playing. At the same time, this demonstrates the importance of the mPXI: for efforts such as GeoExplorer many more measures are needed and a shorter, more succinct measure of PX would be valuable. In the case of GeoExplorer, for example, we measured, among others, students' learning, motivation, and career ambitions. For GeoExplorer specifically, the results further suggest that while the average satisfaction is decent with a score of 7.50 out of ten, room for improvement exists to improve the PX.

5.1.2 The Issue of Immersion. One result is clear and this is that Item #3, "I was no longer aware of my surroundings while I was playing," does not fit well. Although future work can easily replace this item with one of the other two items that belong to the Immersion construct, it is important to reflect on this, especially given that this statement appears in the exact same or somewhat similar form in many survey instruments. A hint is that participants agreed much less with this statement compared to others. This may suggest that for GeoExplorer specifically, or with educational games potentially at large, players are less fully immersed compared to playing entertainment games. A possible explanation is that players participate in these activities as part of a course and so they may actively think about and reflect on what they are doing related to the course. Future work should consider if indeed a difference exists between educational/serious games and entertainment games and if an adjusted PXI/mPXI is needed for these particular games, and what Immersion item fits better. In our future work with the mPXI, we intend to replace Item #3 with "I was fully focused on the game."

5.1.3 1-Factor vs. 2-Factor. As part of this effort we examined if a 1-factor solution, that is, one that simply measures PX, or a 2-factor solution, one that aligned with the original PXI distinguishes PX into Functional Consequences (FC) and Psychosocial Consequences (PC), is more feasible and thus should be adopted. In favor of the 1-factor solution is that it has excellent reliability, is parsimonious, and that the discriminant validity of the 2-factor solution is somewhat questionable. In contrast, the 2-factor solution explains more variance and is based on a validated theoretical model. More importantly, our work more or less identically replicates the results found by Vanden Abeele et al. [3], see Figure 1. We should, however, note that our EFA did not replicate the model. While Item #7 should be further investigated in future work (i.e., loading < .40), Items #1 and #2 are of particular concern because they loaded high on FC and not PC (see Table 1). In short, our work does not provide conclusive evidence on this matter. Both seem feasible but based on our current findings we recommend using the 1-factor solution. While this negates the underlying theoretical model of the PXI, if researchers are very interested in the low-level details, they should use the original PXI. Importantly, this also shows that the mPXI should not be seen as a replacement for the PXI, but rather that it is a shortened version to measure PX where researchers do not have the need or the ability to measure PXI with all its facets.

5.1.4 mPXI?. The question is if the mini Player Experience Inventory (mPXI) is a valid instrument. It is too early to determine that, especially as it has been used in only one context thus far. Of concern is that the variance explained is relatively low, lower than the recommended 60% in the social sciences [24]. Removal of Item #3 in the EFA would lead to 46% and 52% for the 1-factor and 2-factor solution, respectively, which is an improvement but still lower than recommended. Another issue are the inter-item correlations. For a good model fit, the covariances between Items #1 and #2, #4 and #5, and #8 and #10 needed to be included. All these make *theoretically* sense: how meaningful a game is relates closely to being able to succeed, especially in an educational game; freedom to play is similar to discovering how the game continues an act of exploration; and progress towards the goals and clear goals are both about the game element of goals. It may be necessary to include items that are more independent yet still measure the construct they are associated with. However, inter-item correlations are to be expected and future work can include these in their CFA models a priori.

5.2 Limitations

In this work, a clear limitation is that we applied the mPXI to a single educational game. This specific context and genre may have influenced the results, as well as that playing the game happened during COVID-19. For further scale development, the mPXI should be applied to other games and audiences. If possible, future work should also consider including the entire PXI so a correlation matrix can be used to determine what items should be included.

There are other recommended methods for conducting CFA [1, 27], specifically if Likert/ordinal scale data is used. While other recommend methods result in a poorer fit, the same patterns are observed as demonstrated in Table 2. Furthermore, it is generally not recommended to use EFA and CFA on the same dataset (e.g., [19, 20]). However, we argue that in our case the use of CFA on the same data was warranted because we both aimed to explore the data structure of a new scale as well as test its structure according to the original PXI and not based on the EFA results, which is what most of the literature warns against.

6 CONCLUSION

In this work-in-progress paper, we present the preliminary development and evaluation of the mini Player Experience Inventory (mPXI), a shortened 10-item survey instrument based on the original 30-item PXI. In applying the mPXI to an educational game in engineering education, we find promising but inconclusive evidence. We were able to replicate some of the findings, but also find inconsistencies that warrant further investigation. Based on this work, we recommend continuing to explore a 10-item mPXI that replaces the Immersion item and is used as a single measure of PX.

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REFERENCES

[1] Amir Zaib Abbasi, Ding Hooi Ting, Helmut Hlavacs, Liliana Vale Costa, and Ana Isabel Veloso. 2019. An empirical validation of consumer video game engagement: A playful-consumption experience approach. *Entertainment Computing* 29 (2019), 43–55.

[2] Tarek Abdoun, Casper Harteveld, Waleed El-Sekelly, D Grover, V Bennett, U El Shamy, and Flora McMartin. 2016. A mixed reality field testing educational game for geo-engineering education. In *Geotechnical & Structural Engineering Congress.*

[3] Vero Vanden Abeele, Katta Spiel, Lennart Nacke, Daniel Johnson, and Kathrin Gerling. 2020. Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences. *International Journal of Human-Computer Studies* 135 (2020), 102370.

[4] Ahmad Azadvar and Alessandro Canossa. 2018. UPEQ: ubisoft perceived experience questionnaire: a self-determination evaluation tool for video games. In *Proceedings of the 13th international conference on the foundations of digital games.* 1–7.

[5] Aaron Bangor, Philip T Kortum, and James T Miller. 2008. An empirical evaluation of the system usability scale. *Intl. Journal of Human–Computer Interaction* 24, 6 (2008), 574–594.

[6] MT Barendse, FJ Oort, and ME Timmerman. 2015. Using exploratory factor analysis to determine the dimensionality of discrete responses. *Structural Equation Modeling: A Multidisciplinary Journal* 22, 1 (2015), 87–101.

[7] Victoria Bennett, Tarek Abdoun, Casper Harteveld, Flora P McMartin, and Usama El Shamy. 2017. Classroom implementation of game-based module for geotechnical engineering education. In *124th ASEE Annual Conference and Exposition, Conference Proceedings.* 1–10.

[8] Victoria G Bennett, Casper Harteveld, Tarek Abdoun, Usama El Shamy, Flora McMartin, Binod Tiwari, and Anirban De. 2020. Implementing and Assessing a Game-Based Module in Geotechnical Engineering Education. In *Geo-Congress 2020: Geotechnical Earthquake Engineering and Special Topics.* American Society of Civil Engineers Reston, VA, 676–684.

[9] Tom Boellstorff, Bonnie Nardi, Celia Pearce, and Tina L Taylor. 2012. *Ethnography and virtual worlds: A handbook of method.* Princeton University Press.

[10] Jeanne H Brockmyer, Christine M Fox, Kathleen A Curtiss, Evan McBroom, Kimberly M Burkhart, and Jacquelyn N Pidruzny. 2009. The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. *Journal of Experimental Social Psychology* 45, 4 (2009), 624–634.

[11] John Brooke. 1996. SUS: a "quick and dirty'usability. *Usability evaluation in industry* (1996), 189.

[12] Florian Brühlmann and Elisa D Mekler. 2018. Surveys in games user research. In *Games User Research*, A. Drachen, P. Mirza-Babaei, and L.E. Nacke (Eds.). Oxford University Press, 141–162.

[13] Fred B. Bryant and Paul R. Yarnold. 1995. Principal-components analysis and exploratory and confirmatory factor analysis. In *Reading and understanding multivariate statistics.* American Psychological Association, Washington, DC, US, 99–136.

[14] Peter Cabrera-Nguyen. 2010. Author guidelines for reporting scale development and validation results in the Journal of the Society for Social Work and Research. *Journal of the Society for Social Work and Research* 1, 2 (2010), 99–103.

[15] M-T Cheng, H-C She, and Leonard A Annetta. 2015. Game immersion experience: its hierarchical structure and impact on game-based science learning. *Journal of Computer Assisted Learning* 31, 3 (2015), 232–253.

[16] Alena Denisova, A Imran Nordin, and Paul Cairns. 2016. The convergence of player experience questionnaires. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play.* 33–37.

[17] Heather Desurvire and Magy Seif El-Nasr. 2013. Methods for game user research: studying player behavior to enhance game design. *IEEE computer graphics and applications* 33, 4 (2013), 82–87.

[18] Magy Seif El-Nasr, Anders Drachen, and Alessandro Canossa. 2016. *Game analytics.* Springer.

[19] Leandre R Fabrigar, Duane T Wegener, Robert C MacCallum, and Erin J Strahan. 1999. Evaluating the use of exploratory factor analysis in psychological research. *Psychological methods* 4, 3 (1999), 272.

[20] Marjolein Fokkema and Samuel Greiff. 2017. How performing PCA and CFA on the same data equals trouble: Overfitting in the assessment of internal structure and some editorial thoughts on it. *European Journal of Psychological Assessment* 33, 6 (2017), 399–402. https://doi.org/10.1027/1015-5759/a000460 Place: Germany Publisher: Hogrefe Publishing.

[21] David Goretzko, Trang Thien Huong Pham, and Markus Bühner. 2019. Exploratory factor analysis: Current use, methodological developments and recommendations for good practice. *Current Psychology* (2019), 1–12.

[22] Jonathan Gutman. 1982. A means-end chain model based on consumer categorization processes. *Journal of marketing* 46, 2 (1982), 60–72.

[23] Jonathan Gutman and Thomas J Reynolds. 1979. An investigation of the levels of cognitive abstraction utilized by consumers in product differentiation. *Attitude research under the sun* (1979), 128–150.

[24] Joseph F Hair, William C Black, Barry J Babin, Rolph E Anderson, Ronald L Tatham, et al. 1998. *Multivariate data analysis.* Vol. 5. Prentice hall Upper Saddle River, NJ.

[25] D Hooper, J Coughlan, M Mullen, and D Hooper. 2008. Structural equation modelling: guidelines for determining model fit. *Electron J Bus Res Methods* 6, 1 (2008), 53–60.

[26] Daniel Johnson, M John Gardner, and Ryan Perry. 2018. Validation of two game experience scales: the player experience of need satisfaction (PENS) and game experience questionnaire (GEQ). *International Journal of Human-Computer Studies* 118 (2018), 38–46.

[27] Cheng-Hsien Li. 2016. Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares. *Behavior research methods* 48, 3 (2016), 936–949.

[28] Pejman Mirza-Babaei, Sebastian Long, Emma Foley, and Graham McAllister. 2011. Understanding the Contribution of Biometrics to Games User Research.. In *DiGRA conference.* Citeseer.

[29] Laura L Swisher, Jason W Beckstead, and Muriel J Bebeau. 2004. Factor analysis as a tool for survey analysis using a professional role orientation inventory as an example. *Physical Therapy* 84, 9 (2004), 784–799.

[30] Josef Wiemeyer, Lennart Nacke, Christiane Moser, et al. 2016. Player experience. In *Serious Games.* Springer, 243–271.