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Design of Customizable Gamified Augmented Reality Apps: Towards Embracing Active Learning

Mas Nida MD KHAMBARI[a*], Dan WANG[b], Su Luan WONG[c] , Priscilla MOSES[d], Mohd. Najwan MD. KHAMBARI[e], Rahmita Wirza O.K. RAHMAT[f], & Fariza KHALID[g]
[abcf]*Universiti Putra Malaysia, Malaysia*
[d]*Universiti Tunku Abdul Rahman, Malaysia*
[e]*Universiti Teknikal Melaka, Malaysia*
[g]*Universiti Kebangsaan Malaysia, Malaysia*
*khamasnida@upm.edu.my

Abstract: Educators worldwide are facing challenges to continue providing quality learning design remotely, digitally and in virtual settings. Although teaching and learning activities are almost relatively easy to be translated to online platforms, education is missing active learning and social presence, both of which can promote effective learning. When digital education ensues, mobile technologies are widely optimized for learning. The Malaysian Communications and Multimedia Commission report shows that smartphones have become the most popular devices to access the Internet, reaching a near saturation usage level at 98.7% in 2020, due to the pandemic. In the aftermath of the COVID-19 pandemic, more education institutions will continue to conduct virtual lessons, and the trend is set to grow exponentially. The XploreRAFE+ mock-up mobile apps was developed with the aim of gamifying learning and foster active learning, framed by the Interest-Driven Creator Theory. In general, people who play games may experience positive activating emotions. Positive activating emotions such as enjoyment and pride are found to be positively correlated with cognitive regulations (Yeo & Frederiks, 2011). This is what XploreRAFE+ aims for its users to achieve — able to internalize the knowledge through game play and therefore, enhance their cognition. As such, this apps was designed to allow instructors who do not have the technological know-how of gamification and Augmented Reality (AR), to be able to embrace both for their learning design. Rather than spending time and effort laboriously on designing a gamified lesson with virtual contents, instructors are now able to save their time and create a gamified lesson by plugging in their content into this apps, choosing AR overlays, selecting game mechanics and eliciting students' learning feedback through ePortfolio. XploreRAFE+ would be able to add value by adding in the affective aspects, virtual extended reality elements, supporting social presence and intimacy, and immediacy of feedback. This study invites further research on the apps' evaluation after its development is fully completed.

Keywords: Gamification, Augmented Reality, Active Learning, Apps Design, Interest-Driven Creator Theory

1. Introduction

As COVID-19 pandemic ensues and has forced many sectors including the educational institutions to shut down, challenges arose among educators on how to continue providing quality learning design remotely, digitally and in virtual settings. This has posed more challenges to educators to ensure that the learning objectives are successfully delivered, hence successfully achieved by students. Thus, crafting a learning design through a universal gamified active learning apps that could address these concerns became the central focus of this proposed study.

Although teaching and learning activities are almost relatively easy to be translated to online platforms, education is missing one of its mainstays, namely active learning and social presence such as intimacy and immediacy of feedback, which can be promoted through gamification (O'Connel, Tomaselli, Stobart-Gallagher, 2020). Drawing on the Universal Learning Design principles, this research proposes a universal and customizable gamified active learning apps that aims at providing

multiple means of engagement, representation, action and expression (CAST, 2018). Through this approach, instructors will be able to eliminate common barriers and struggles among learners. Research found that, in order to promote students' learning, one of the most effective learning approaches is active learning (Crouch & Mazur, 2001; Deslauriers Schelew, & Wieman, 2011; Haak, HilleRisLambers, Pitre, & Freeman, 2011;
Nehm & Reilly, 2007).

Although there are several benefits of gamification, active learning, and AR technologies can be found, perhaps, it is also worth to take into account that most instructors are not ready to gamify their lessons as they are lacking the technological know-hows. In most cases, many people are involved in games as consumers, and not as designers or developers (Sawahel, 2020). Integrating gamification and active learning into teaching needs a careful instructional design process so that the quality of knowledge remains a priority, thus larger that the "fun of playing." This is in line with the concerns by Andrews, Leonard, Colgrove and Kalinowski (2011), who warned that most instructors lack the rich and nuanced understanding of teaching and learning that may cause superficial resemblance of active learning hence lacks the constructivist elements necessary for improving learning.

Nevertheless, a report by the Malaysian Communications and Multimedia Commission highlighted that accessing the Internet using mobile devices have reached an almost saturated usage level at 98.7%. Meanwhile, the usage of other devices to access the Internet – such as laptops, desktops, smart TVs, and game consoles, have declined significantly for the past two years MCMC, 2020). Interestingly, while the percentage of users who use the Internet to acquire information (85.5% to 74.3%) and to study (60.2% to 29.7%) has decreased at an alarming rate in 2020, the percentage number of users who engage in online games have also increased from 35.2% in 2018 to 42.8% within the same timeline. This can be seen as an opportunity for educators to modify their learning design by optimizing mobile technologies. In the COVID-19 pandemic, integrating gamification may offer a level of engagement to learners to compensate for missing face-to-face classroom activities.

Gamification and active learning, two contemporary approaches that reciprocate one another in enhancing instruction and augmenting instructors to achieve students' outcomes, are gaining popularity. However, without proper curation for meshing elements from both approaches, knowledge quality may be jeopardized. Therefore, there is a need for a systematic apps that could allow and assist educators to customize and personalize his/her own gamified-active learning environment even if they have the minimum, or perhaps do not possess, the 'know-how' skills.

Taking advantage of the pandemic situation that has caused an almost saturation usage level of mobile technologies to access the Internet (98.7%) in 2020, this research has designed a customizable-and-universal gamified AR mobile apps embedded with ePortfolio, Augmented Reality and geo-location tags, that both instructors and learners can benefit from. These features, when compiled together in a single apps, allows intimacy that can fill in as the social presence of a remote learning, immediacy of feedback and interaction between learners and instructors.

According to Steiler-Hunt and Jones (2015), educators need to experience the games themselves in order to find games valuable. This is because those who have played games/involved in game design will be able to reuse this experience as a palette of reference when they want to design games in the future, as game design can provide elaborate representation of play and enthusiasm. Through experiential inspiration they gained from the use of XploreRAFE+, educators will be able to have an inspiration how games are developed and carried out through the step-by-step guidelines in the apps.

2. Literature Review

Emerging contemporary approaches to learning such as gamification and active learning have gained interests and being practised in many parts of education. Gamification borrows the elements of game mechanics to integrate into non-gaming context (Deterding, Khaled, Nacke, & Dixon, 2011) namely in teaching, to create a fun and engaging learning atmosphere (Deslis, Kosmidis & Tenta, 2019; Md. Khambari, 2018a, Md. Khambari, 2018b, Amir & Ralph, 2014) as learners play and learn through playing the games, themselves. Gamification is an increasingly popular method of educational instruction that incorporates game mechanics into learning design. Gamification is characterized by competition which stimulates students' interest and participation in the learning process (Kim,

Rothrock & Freivalds, 2016). Students beat rivals, become winners and contribute their own efforts to their team. In higher education, the most commonly utilized techniques are points, badges, levels and leader boards (Alomari, Ai-Samarraie & Yousef, 2019).

Past studies have proven that gamification is regarded as an innovative learning design that can foster knowledge improvements, soft skills, motivation, and satisfaction as compared to traditional education methods in many studies (Gentry, Gauthier, L'Estrade-Ehrstrom (2019), Rosly & Khalid, 2017, Kim, Rothrock & Freivalds, 2016, Plass, Homer & Kinzer, 2015; Hussain, Tan & Idris, 2014; Sailer, Hense, Mandl & Klevers, 2013) as it allows the freedom for trial-and-error and encourages "exploration, collaboration, and the exchange of ideas while removing unwanted pressures that can interfere with students' abilities" (Cohen, 2011, p. 17). When gamification is employed, users or students who played the game, should feel that the activity is important to them and thereby will be self-motivated to perform it. Basically, gamification in instruction uses the motivational power of games but in the context of education to enhance and diversify the teaching approach and foster self-driving behavior.

Meanwhile, active learning is a non-traditional approach to learning whereby learners are put into autonomy of their own learning by actively participating in class activities and discussions that can help them construct new knowledge and skills (Carr, Palmer & Hagel, 2015, Freeman, et al., 2014; Handelsman, 2007) rather than merely knowledge transmission between teacher and students. The findings from research related to gamification often come hand-in-hand with research studies related to active learning. Research reveals a mutual influence between active learning and emotional states.

Active learning can positively affect student motivation (Owens, Sadler, Barlow & Smith-Walters, 2017); in turn, the overall impact of motivation moderates key learning characteristics such as attention and memory consolidation (Cavanagh et al., 2016). Furthermore, there are well-established empirical research studies that highlights the benefits of active learning. The benefits to using such activities are many, including improved student outcomes (Ruiz-Primo et al., 2011) and critical thinking skills (Prince, 2004), increased retention and transfer of new information, increased motivation, improved academic and interpersonal skills (Kuh, O'Donnell, and Schneider, 2017), and decreased course failure rate (Freeman et al., 2014). Pairing the elements of gamification with active learning, each of which is of value in itself, can be greater than the sum of the total, thus multiplying the efficacy of the learning process.

Overlaying virtual elements such as Augmented Reality (AR) may boost the digital learning experience among learners. AR technology can attract students to interact with the real environment, which was before considered as an impossible learning approach (Billinghurst, 2002). The report of America Technology Virtual and Augmented Reality points out that "AR technology has the potential to be a standard tool in education and could revolutionize the way in which students are taught for both the K-12 segment and higher education (college and beyond)" (Sachs, 2016, p. 25). AR technology can combine different forms of virtual materials such as virtual figures, vivid animation and sound to construct a real and virtual learning environment to effectively enhance learning motivation (Liu, Tan & Chu, 2010; Solak & Cakir, 2015). Moreover, AR technology has also been proven to incorporate interaction function, providing more opportunities for students to engage themselves in a learning activity (Wang, 2017). Besides, gamification has been proven to be one of the most significant applications of AR technology in teaching (Bicen & Bal, 2016).

Findings of past studies show that gamification learning approaches supported by AR technology are widely applied in different disciplines (Bicen & Bal, 2016; Delello, 2014). AR technology can be effectively combined with gamification to construct an attractive learning environment to enhance student learning interest (Faisal, 2017; Bicen & Bal, 2016). AR technology can effectively combine the form of gamification to construct an attractive learning environment (Faisal, 2017). Some researchers have already emphasized the useful aspects of AR and gamification in learning and teaching (Mesut & Katrin, 2020; Faisal, 2017).

3. Design of the Apps and Underlying Theory

Based on the literature, the design of XploreRAFE+ seeks to address the aforementioned issues and aspires to offer solutions to educators who wish to integrate gamification and active learning into their instruction, even if they do not possess the technological know-hows of the aforementioned

approaches. Features embedded with gamification elements (GE) are aligned with active learning elements (ALE) to achieve learning goals and capture several analytics that reflect immersive, meaningful, self-driven and self-paced learning. We outlined the design and hypotheses for each of the game elements as follows:

Table 1. *Design and Hypothesis for The Apps*

Element / Game Mechanics	**Function**	**Hypothesis**
Progress timer	Capture learners' ability to solve a problem (ALE) within a specific time frame (GE)	Progress timer can foster critical thinking when learners had to work under slight pressure
Leader board	Add elements of competitiveness	Leader board can instill collaborative skills among learners to achieve a common goal
Geo-location tagged check-points (GPS) with rewards	Deliver information or tasks to the learners	Geo-location tagged check-points (GPS) with rewards (GE) can foster interaction between learners and their surroundings and relate with real life experience
ePortfolio with badges	Platform for learners to reflect their knowledge and learning	ePortfolio with badges (GE), can initiate dialogue between instructors and learners, construct and internalize new knowledge (ALE)
Augmented Reality	Will appear at the check-points to deliver information or tasks to the learners	Augmented Reality can trigger curiosity among learners in a socially mixed-reality interactive setting (ALE)

Through the use of this apps, the instructors will be assisted on how and what to plug-in according to the lesson context, so that they can create a gamified-active learning instruction. For the instructor's interface/module, a function named analytics will be made available at the dashboard. Through this, instructors could garner data analytics of their students' learning behaviour, thinking process and performances through the embedded features (like progress timer, leaderboard, ePortfolio, etc.). This function will allow instructors to view students' name, identification number, response time, score, attempts (to respond), leaderboard, and reflections (through eportfolio). The data from the analytics can provide trends or patterns and act as a jumping board for instructors to understand their learners' needs, attitude, and behavior. This can be useful to the instructors to better understand and predict students' personal needs and performance, thus further supporting their learning.

The Interest Driven Creator (IDC) theory by Chan et al. (2018) was applied to guide the development of the proposed apps as it is crucial that students' interest on the lesson be piqued even before the start of the lesson. The IDC theory posits that technology enhanced lessons that are designed using the IDC theory will trigger students' interest in learning and immerse them in the creation process and this in turn strengthen their habits of creation. Chan and his team (2018) hypothesized that such students will excel in their learning performance with developed 21st century competencies and become lifelong interest-driven creators. From the theory, the interest loop that consists of three stages, namely triggering, immersing and extending, is applied in the design of the apps. The first stage, triggering, is characterized in the Augmented Reality and GPS function design where learners have to hunt and uncover some information/knowledge through Augmented Reality. The second stage, immersing, is characterized by the flow of the game play with leaderboards, timers, and tasks that they have to solve along the way. While the third stage, extending, is characterized in the ePortfolio where learners will be able to share their experiences and write reflections on their learning process.

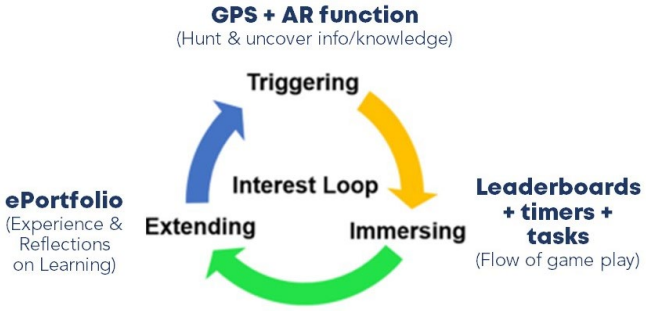

Figure 1. IDC Theory underpinning the apps design.

Consequently, student users of XploreRAFE+ will get better access to learning and the opportunity to experience gamification and active learning. Through their involvement in the gamified-active learning lesson, learners will achieve the learning outcomes of the topic with added value such as soft-skills and digital mobile skills. The tasks given in games functions and the ePortfolio functions are forms of alternative assessment to the learners. Instructors will be able to engage students during assessment by injecting elements of fun and curiosity. Given that instructors have the opportunity to input their own subject matter content into the apps, instructors will be able to constructively align the content to the tasks and ePortfolio, and to the learning outcomes.

4. Conclusion

This study outlined the design and proposed to develop a customizable-and-universal gamification and AR apps for learning design, aimed at helping educators to embrace active learning through gamification, even if they have minimum to no-basics of technological know-hows of this approach. Given the current pandemic where learning occurs mostly at home, this apps makes it possible for learners to be motivated during online lessons. Even when the pandemic subsides, the proposed designed apps will open up more opportunities for scholars and innovators to grind solutions that can pave the way forward for digital and virtual learning. We hope that the proposed apps will be relevant in most learning environments. This study invites further research on the apps' evaluation, be it qualitative or quantitative in nature, after its development has fully completed.

References

Amir, B. & Ralph, P. (2014). Proposing a theory of gamification effectiveness. ICSE'14. Hyderabad, India.

Andrews, T. M., Leonard, M. J., Colgrove, C. A. & Kalinowski, S. T. (2011). Active Learning Not Associated with Student Learning in a Random Sample of College Biology Courses. Life Sciences Education, 10, 394-405.

Beldarrain, Y. (2006). Distance Education Trends: Integrating new technologies to foster student interaction and collaboration. Distance Education, 27(2), 139–153. doi:10.1080/01587910600789498

Bicen, H., & Bal, E. (2016). Determination of Student Opinions in Augmented Reality. World Journal on Educational Technology: Current Issues, 8(3), 205-209.

Bluestein, J. (2014). Managing 21st Century Classrooms: How do I avoid ineffective classroom management practices? ASCD: USA.

Carr, R., Palmer, S., and Hagel, P. (2015). Active learning: the importance of developing a comprehensive measure. Active Learning in Higher Education 16, 173-186.

CAST (2018). Universal design for learning guidelines version 2.2 [graphic organizer]. Wakefield, MA: Author.

Cavanagh, A. J., Aragón, O. R., Chen, X., Couch, A., Durham, F., Bobrownicki, A., Hanauer, D. I., Graham, M. J. (2016). Student Buy-In to Active Learning in a College Science Course. CBE life sciences education, 15(4), 1-9.

Chan, T. W., Looi, CK., Chen, W. et al. Journal of Computers and Education. (2018) 5: 435. https://doi.org/10.1007/s40692-018-0122-0

Chattaraj, D., Vijayaraghavan, A.P. (2021) Why learning space matters: a script approach to the phenomena of learning in the emergency remote learning scenario. Journal of Computers in Education. https://doi.org/10.1007/s40692-021-00182-z
Cohen, A. M. (2011). The gamification of education. The Futurist, 45(5), 16-17.
Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. American Journal of Physics, 69, 970-976.
Davis, B. G. (1993). Tools for Teaching. San Franciso, CA: Jossey-Bass.
Delello, J. A. (2014). Insights from pre-service teachers using science-based augmented reality. Journal of computers in education, 1(4), 295-311.
Deslauriers L., Schelew E., & Wieman C. (2011). Improved learning in a large-enrollment physics class. Science, 332, 862–864.
Deslis, D., Kosmidis, C.V. & Tenta, E. (2019). Using a Noneducational Mobile Game for Learning in Biology, Geography and Mathematics: Pokémon Go as a Case Study, International Conference on Technology and Innovation in Learning, Teaching and Education, pp.388-396.
Deterding, S., Khaled, R., Nacke, L., & Dixon, D. (2011). Gamification: Towards a definition. Proceedings of the 2011 annual conference extended abstracts on human factors in computing systems, ACM.
Epstein, M., Atkins, M., Cullinan, D., Kutash, K., & Weaver, R. (2008). Reducing behavior problems in the elementary school classroom: A practice guide. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.
Faisal, S. (2017). Gamification of Foreign-Language Vocabulary Learning using Mobile Augmented Reality. Retrieved from https://www.researchgate.net/publication/327920037_Gamification_of_ForeignLanguage_Vocabulary_Learning_using_Mobile_Augmented_Reality.
Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., and Wenderoth, M.P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences USA, 111, 8410-8415.
Gentry V, Gauthier A, L'Estrade Ehrstrom B, et al.: Serious gaming and gamification education in health professions: systematic review. J Med Internet Res. 2019, 21:e12994. 10.2196/12994
Haak, D., HilleRisLambers, J., Pitre, E. & Freeman, S. (2011). Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology. Science, 332(6034), 1213-1216.
Handelsman, J., Miller, S., and Pfund, C. (2007). Scientific teaching. New York: W.H. Freeman.
Hussain, S. Y. S., Tan, W. H., & Idris, M. Z. (2014). Digital game-based learning for remedial mathematics students: A new teaching and learning approach In Malaysia. International Journal of Multimedia Ubiquitous Engineering, 9 (11), 325-338
Jagust, T., Boticki, I., Mornar, V. & So, H.J. (2017). Gamified Digital Math Lessons for Lower Primary School Students, 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI), 9-13July 2017, Hamamatsu, Japan
Kuh, G., O'Donnell, K. & Schneider, C. G. (2017) HIPs at Ten, Change: The Magazine of Higher Learning, 49:5, 8-16.
McKeachie, W. J. (2006). Teaching Tips: Strategies, Research and Theory for learning. Science 331, 1269–1270.
MCMC (2020). 2019 Universal Service Annual Report. 14 December 2020. Retrieved from https://www.mcmc.gov.my/skmmgovmy/media/General/pdf/MCMC-USP2019AR-ENG.pdf
Md. Khambari, M. N. (2016). Innovating a Meaningful Gamified Instruction: An Instructor's Quest to Fulfill the Demands of 21st Century Learners. In Chen, W. et al. (Eds.) (2016). Proceedings of the 24th International Conference on Computers in Education. India: Asia-Pacific Society for Computers in Education. India: Asia-Pacific Society for Computers in Education.
Md. Khambari, M. N. (2018a). Students' Perspectives on an Augmented Reality Embedded Gamification Kit for Learning. In Wong Su Luan & Zalina Mohd. Kasim (Eds.). Trends and Issues in Higher Education. Serdang: Center for Academic Development. pp.1-6.
Md. Khambari, M. N. (2018b). Blending Gamification and Augmented Reality in XploreRAFE+ Module: Intriguing Excitement and Promoting Collaborative Learning among Learners in Higher Education. In Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education.
Mesut, A., & Katrin, T. (2020). Gamification in an Augmented Reality Based Virtual Preparation Laboratory Training. In the challenges of the digital transformation in education. doi:10.1007/978-3-030-11932-4_54.
Minister of Education Malaysia (2019). Pendidikan untuk Semua, Tanggungjawab Semua. Retrieved from www.moe.gov.my
Ministry of International Trade and Industry (2018). Industry 4WRD: National Policy on Industry 4.0. MITI: Malaysia.
Ministry of Education Malaysia (2015). Executive Summary Malaysia Education Blueprint 2015-2025 (Higher Education). Retrieved from www.moe.gov.my

Nehm R. H., Reilly, L. (2007). Biology majors' knowledge and misconceptions of natural selection. BioScience 57, 263–272.
O'connell A, Tomaselli P J, Stobart-Gallagher M (June 01, 2020) Effective Use of Virtual Gamification During COVID-19 to Deliver the OB-GYN Core Curriculum in an Emergency Medicine Resident Conference. Cureus 12(6): e8397. doi:10.7759/cureus.8397
Owens, D.C., Sadler, T. D., Barlow, A. T. & Smith-Walters, C. (2017). Student Motivation from and Resistance to Active Learning Rooted in Essential Science Practices. Springer.
Prince, M. (2004). Does Active Learning Work? A Review of the Research. Journal of Engineering Education, 93(3), 223-231.
Rosly, R. M. & Khalid, F. (2017). Gamifikasi: Konsep dan Implikasi dalam Pendidikan. In. R Mohamed Rosly, N. A. Razali & N. A. Jamilluddin. (Eds.)., Pembelajaran Abad ke-21: Trend Integrasi Teknologi (pp 144- 154). Bangi: Fakulti Pendidikan UKM.
Ruiz-Primo, M.A., Briggs, D., Iverson, H., Talbot, R., Shepard, L.A. (2011). *Impact of undergraduate science course innovations on Learning, 331*(6022), 1269-1270
Sailer, M., Hense, J., Mandl, H., & Klevers, M. (2013). Psychological Perspectives on Motivation through Gamification. IxD&A, 19, 28-37.
Sawahel, W (2020) Gamification of education could engage students during COVID-19. University World News: Africa Edition. 26 No vember 2020. Retrieved from https://www.universityworldnews.com/post.php?story=20201123063309960
Smith, A. C., Stewart, R., Shields, P., Hayes-Klosteridis, J., Robinson, P., & Yuan, R. (2005). Introductory biology courses: A framework to support active learning in large enrolment introductory science courses. Cell Biology Education, 4, 143–156.
Solak, E., & Cakir, R. (2015). Exploring the Effect of Materials Designed with Augmented Reality on Language Learners' Vocabulary Learning. Journal of Educators Online, 12(2), 50-72.
Stieler-Hunt, C. & Jones, C. M. (2015). Educators who believe: Understanding the enthusiasm of teachers who use digital games in the classroom. Journal of Learning Technology, 23 (26155).
Stylianidou, Sofianidis, Manoli & Meletiou-Mavrotheris. (2020). "Helping Nemo!"—Using Augmented Reality and Alternate Reality Games in the Context of Universal Design for Learning, Education Sciences, 10(25), 1-24.
Wang, Y. H. (2017). Exploring the effectiveness of integrating augmented reality-based materials to support writing activities. Computers & Education, 113, 162-176.
Yeo, G. B. & Frederiks, E. R. (2011). Cognitive and affective regulation: scale validation and nomological network analysis. Applied Psychology: An International Review, 60(4), 546-575.