OMEGA: A Multiplayer Online Game for Improving User's Meta-Cognitive Skills

Maiga Chang, Sabine Graf, Patrick Corbett, J. X. Seaton, Scott McQuiod, Tamra Ross
School of Computing and Information Systems
Athabasca University
Athabasca, Canada
maigac@athabascau.ca, sabineg@athabascau.ca

Abstract — **Meta-cognitive skills, like problem solving skills, are extremely important for people. According to recent research done by The Conference Board of Canada, problem solving in technology-rich environments nowadays is positively associated with the probability of participating in the labour market and being employed. Research also shows that a student can be a more confident and independent learner when he or she has better meta-cognitive skills. This research aims to design and develop an educational game that aims at improving four meta-cognitive skills while people are playing. Those skills are: (1) problem solving, (2) associative reasoning, (3) planning and organization and (4) accuracy and evaluation. The research team has a proper evaluation plan designed and research ethics approval obtained for recruiting participants to use OMEGA. This paper also explains the details of the evaluation plan and the instruments of data collection.**

Keywords- meta-cognitive skill; mini game; competition; educational game; game-based learning; browser-based game; problem solving; associative reasoning; accuracy and evaluation; organization and planning

I. INTRODUCTION

Meta-cognitive skills represent a person's ability of understanding, controlling, and manipulating his or her cognitive processes and can be taught so that his or her learning can be improved [31]. When a student has better meta-cognitive skills, he or she can be a more confident and independent learner [1]. Meta-cognitive strategies are different from cognitive strategies. While latter are mentally and/or physically manipulating the material to be learned with previously acquired concepts or skills, the former are built through years of experiences and include self-management or self-regulation, planning, and monitoring strategies that can help people planning for executing a task or pursuing toward a goal, monitoring their efforts and progress, and evaluating how well they have done for the completion of the task or the goal [16].

Meta-cognitive skills are very important in today's economy. While Canada is doing well in producing people with university, college and trade credentials, the actual skill levels in key areas like critical thinking, problem-solving, innovation, etc. are underwhelming [27]. Those skill deficits limit people's potentials and their contributions to their employers, thus, having a negative impact on Canada's economy overall. European Union also lists it as main competences for the 21st century [42].

Assessment is important for education to evaluate and understand students' understandings of knowledge and skills of solving problem tasks. To assess students' knowledge and skills of particular learning topic, teachers usually ask them to take an exam in which a lot of items are included. For example, in Ricketts and colleagues' research the researchers ask students to take eight tests with total 1000 items to evaluate students' knowledge [29]. Students might feel bored and refuse to take the tests, especially when the tests are not directly affecting their academic scores.

Although one-to-one tutoring is proposed and confirmed that it can increase students' achievement by two standard deviations [2], nothing is more important than engaging students to the learning or training process to solving the problem tasks. If students are not motivated in terms of using a method/tool for learning, they will not use it and will not learn no matter how good the method/tool is.

Educational games can make learning more engaging because they are interactive. There are six utilizations of gaming include teaching, experimentation, entertainment, therapy and diagnosis, operations, and training [34]. Numerous educational game research that use gaming for teaching has been done to help students learn languages [8], mathematics and physics concepts [4, 6, 22], programming languages [5, 17], and management information systems [25]. Also, research in the design of games serving different audiences were studied. These include, assisting the elderly to improve skills around selective attention to tasks [7], addressing on-the-job training for adult participants [24], familiarizing financial literacy concepts for youth [15], nurturing the habits of self-regulated learning in adolescents and practice of the knowledge they learned [3], and the training of autistic children in their daily activities skills [18]. Experiments using these games have demonstrated positive and encouraging outcomes regarding student achievement [8, 15].

But simply developing and adopting an educational game in a learning environment does not guaranteed that students' learning motivation can be increased [41]. Even the novelty of an educational game can increase motivation at the very beginning, but that interest will fade over time as the students get used to the game play [40]. It is extremely important for an educational game to include some motivational techniques that can encourage the students continuous playing.

Moreover, some brain training games have been developed by companies like Lumosity, Fitbrains and Cogmed, for training players' memory, attention, speed, etc. [12]. However, cognitive psychologists and neuroscientists could not find any scientific evidence to prove that those games can make users smarter [26].

978-1-7281-4227-2/19/$31.00 ©2019 IEEE
DOI 10.1109/T4E.2019.00-26

This paper introduces OMEGA (see Figure 1), Online Metacognitive Educational Game with Analytics [32, 33], an educational game that includes ten competition-based subgames and each of them can be used to train and assess one of the four meta-cognitive skills targeted by the game: (1) problem solving, (2) associative reasoning, (3) accuracy and evaluation, and (4) organization and planning.

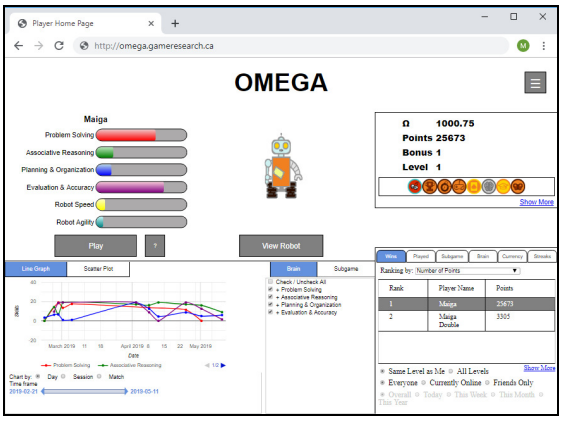

Figure 1. The main screen of OMEGA[1].

In OMEGA, players play matches consisting of a set of three subgames against each other. For each subgame played, a performance score is calculated that shows how well the player played that subgame. A metacognitive skill score for that subgame is calculated based on the performance score as a percentage value compared to the highest possible performance a player can get. The player's overall score for a particular metacognitive skill comes from the highest scores in all subgames associated with the same metacognitive skill.

All of the subgames have 10 levels designed based on the complexity and difficulties. The research proposed the use of Learning Analytics dashboard to help players learn their strengths and weakness and provide them clues on how they can further proceed [32, 33]. With the learning analytics dashboard's help, players would have opportunity to overcome the challengeable and difficult level instead of dropping from keep playing.

From Section II to Section V, the ten subgames are introduced. At the end, Section VI explains the evaluation plan the research team has designed and is ready to start. Section VII concludes the paper with a brief summary and next steps.

II. Problem Solving Subgames

Two subgames, Bypass and Viroid!, are designed and developed that focus on Problem-Solving meta-cognitive skill training and assessment. The end goal of the two subgames is to potentially improve an individual's problem-solving meta-cognitive skill by solving the problems created in each level.

Bypass is a problem-solving game that focuses on two types of problems [14], troubleshooting and rule-based, as the game has both rules that govern the problem (bypassing the broken infrastructure) and allow for flow control and fault states (how game pieces interact with the world). In addition to this, Bypass attempts to solve ill-structured problems, which according to Ruggiero and Green [30] are problems that have more than one outcome or are problems that can result from another problem.

Bypass (see Figure 2) is a competitive puzzle based problem-solving game that challenges players to identify alternative ways to bypass broken underground pipes. Players can either replace existing functional pipes or deploy new pipes with the goal of bypassing the broken infrastructure.

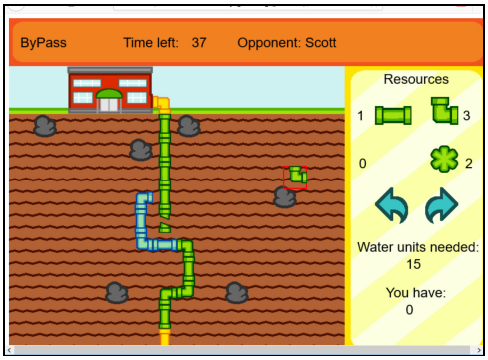

Figure 2. Subgame Bypass for Problem Solving.

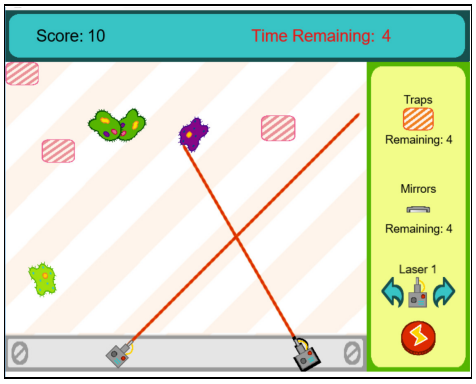

Figure 3. Subgame Viroid! for Problem Solving.

Viroid! focuses on two types of problems [14], logical and rule-based, as the game has a set of logical rules that govern how each player's resources (lasers, mirrors and traps) interacts with non-player controlled resources (infected cells, healthy cells, cell-blocks and walls). Similar to Bypass, in Viroid! players attempt to solve ill-structure problems.

Viroid! (see Figure 3) is an action based problem-solving game that encourages players to identify different approaches to restore infected cells by capturing them using a series of reflective mirrors and movement traps, and then hitting the cells with lasers to transform them to healthy cells.

III. Associative Reasoning Subgames

Three subgames, Crossplay, Pattern Hacker, and Pirate Hunter, are designed and developed that focus on Associative Reasoning meta-cognitive skill training and assessment.

[1] https://omega.athabascau.ca/

Crossplay (see Figure 4) challenges players to identify and play word cards that they feel best associates to the main word that they are presented with. Players must complete as many words as possible until either the timer ends, or when they have reached the maximum number of words for that level. Players are dealt a series of different cards (target domain) that potentially are associated to the main theme and puzzle word (source domain) that are initially presented.

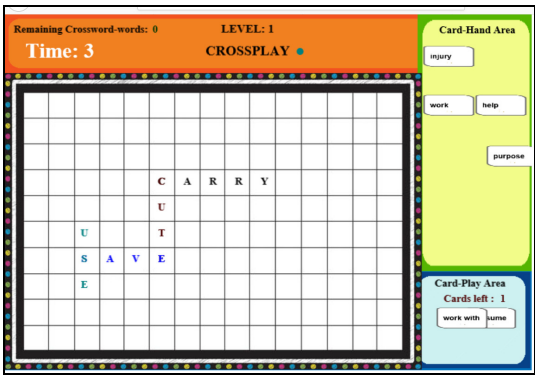

Figure 4. Subgame Crossplay for Associative Reasoning.

Words that are being used are well-defined objects that exist in the external world [28] and by using similar words (synonyms) or directly related words (dictionary words), players are clustering information based off similarities to help create inferences [35]. This method of card distribution supports the ideas that one stimulus can be mapped to another in the same world [21].

The design of Pattern Hacker is inspired by the mental rotation test [39], with the difference that in Pattern Hacker, players are not verifying whether objects are correct but are required to find the forthcoming pattern between each of the objects and continue the pattern to form the last object.

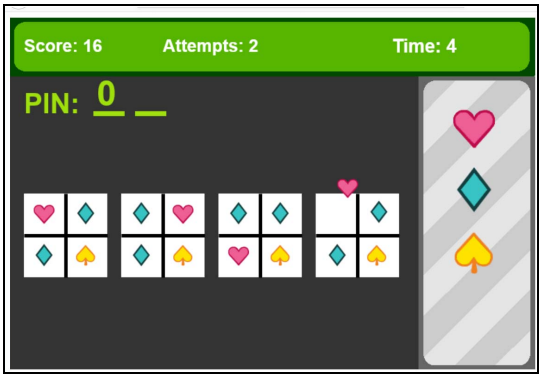

Figure 5. Subgame Pattern Hacker for Associative Reasoning.

In Pattern Hacker (see Figure 5), the player pretends that they are a Hacker that needs to break into someone's account. The account is protected through a PIN which changes on a regular basis. Each number of the PIN is based on four grids of symbols. The player is given information about three grids of symbols. If the player can identify the pattern of those three grids and correctly fill in the fourth grid with the correct symbols, they can unlock a digit of the PIN. If a player can unlock all digits before the PIN changes again, then they can unlock the account.

Pirate Hunter (see Figure 6) is a competitive multiplayer image-association puzzle game that includes two stages. The first stage asks players to determine which picture, out of several, a distorted image was taken from and the second stage challenges players to locate the exact position of the distorted image in the original picture. Pirate Hunter manipulates a key part of the main puzzle picture by either using blurring, colorization or pixilation techniques. This allows a part of the original picture (i.e., a small image) to be obfuscated, which potentially hides the context of the picture. Players need to identify places within the picture that they feel best associate to the situation in the small image, and what they feel has been obscured.

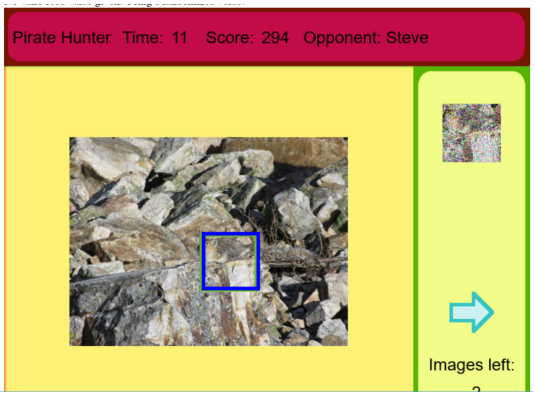

Figure 6. Subgame Pirate Hunter for Associative Reasoning.

By using different obfuscation methods on the main puzzle picture, players need to search for relevant information [23] and must rely on previous experiences or cues [19] from the picture. By doing so, players should be able to identify the new relationships of changes that happened between the original picture and the distorted image.

IV. Accuracy and Evaluation Subgames

Two subgames, Card Swap and Delivery Dash, are designed and developed that focus on Accuracy and Evaluation meta-cognitive skill training and assessment.

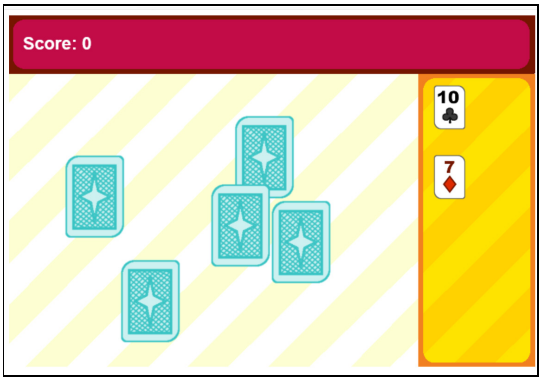

Figure 7. Subgame Card Swap for Accuracy and Evaluation.

Card Swap (see Figure 7) is a card game, which starts with showing several playing cards. Some of the cards are chosen as target cards, which means that the players will have to track the location of those cards once the cards are put upside down and their locations are swapped. The players are scored on how well they find the respective cards and how confident they are in their answers. The game objective is to correctly and confidently identify the position of all the target cards.

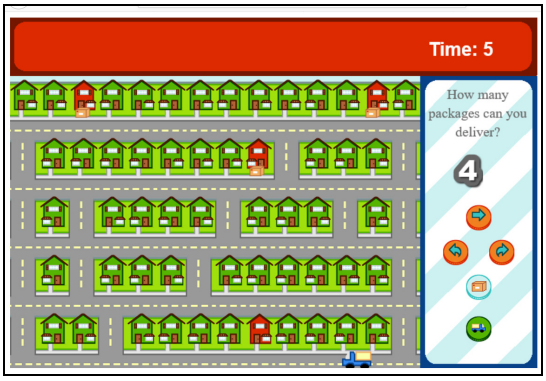

Figure 8. Subgame Delivery Dash for Accuracy and Evaluation.

Delivery Dash (see Figure 8) is a subgame where the players have to program a self-driving truck to make multiple deliveries. The players are able to see the map and where the deliveries are. They are then asked how many deliveries they think they will be able to make in the given time, which will serve to measure the confidence of the player. Once they decide, they can program their truck by pressing the buttons: rotate left, forward, rotate right, and deliver. The players will not be able to see the previous commands that they have given the truck as they program it, so the game will require both attention and some working memory. The players are scored by how many successful deliveries they made, and if they were correct in their guess. The game objective is to correctly and confidently program the truck to make all (or as many as possible) of the deliveries.

V. Organization and Planning Subgames

Three subgames, CR2k, Evacres, and Weekend Barista, are designed and developed that focus on Organization and Planning meta-cognitive skill training and assessment.

CR2k (see Figure 9) encourages players to organize a cycling trip by performing route and equipment planning and organization. Players are exposed to different events that potentially hinder or benefit them during their trip. Players can use equipment to mitigate and/or benefit from those events, however players need to reach the end of the route before running out of energy or risk losing the game.

While CR2k tries to simulate some of the elements of a cycling trip, the game is primary a non-technical simulation that supports the concept of improving route planning skills (organization and planning) as well as planning for positive and negative events through game simulation [20] by creating levels with multiple routes with different sets of observable positive or negative events [9].

Evacres (see Figure 10) encourages players to organize and plan how to maximize the value of their land tiles by attempting to exploit positive events and mitigating negative events. Players are given random land tiles (resources) and are presented with random events that can have positive, negative or unknown impact. Players play action cards to attempt to benefit or mitigate the events. The objective of the subgame is to place the action cards in a way that the events lead to the best possible outcome.

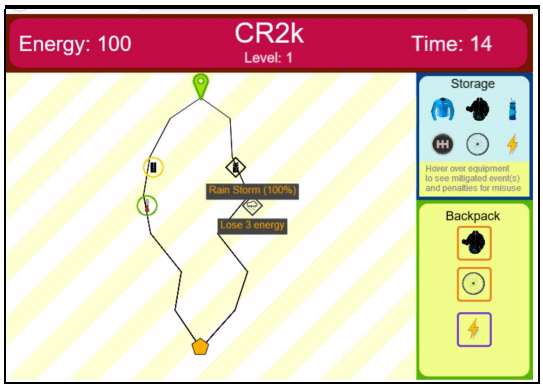

Figure 9. Subgame CR2k for Organizaing and Planning.

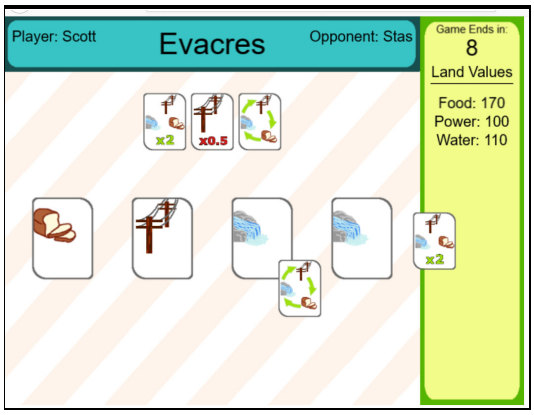

Figure 10. Subgame Evacres for Organizaing and Planning.

Beside benefiting from meta-cognitive strategies via planning of land and actions while observing events, Evacres also allows player to select which action cards they wish to play, which means players are able to have self-control over their actions and set their own goals, which is part of being an active learner [10] and have control over how they address aspects of strategic planning, such as dealing with threats and opportunities [13].

Weekend Barista (see Figure 11) encourages players to organize and plan resources and priorities (regular and special coffee orders) of a coffee shop that are needed to complete the weekend orders. Players have different types of resources they need to manage while trying to predict to an extent the amount of special orders compared to regular orders that they might receive based on various factors, including the weather. Each subgame consists of two rounds representing Saturday and Sunday. Players have the choice to modify their resources at the start of each day.

Similar to both CR2k and Evacres, players need to use meta-cognitive learning strategies to observe upcoming event conditions and plan out what course of action they wish to take in order to benefit the most from them.

Similar to CR2k, Weekend Barista players need to manage their resources (cup sizes, sugar, cream and ice) while trying to predict the usage of those resources throughout the weekend.

While Weekend Barista is simulating a coffee shop environment, it is not simulating the technical side of brewing coffee, but more of the non-technical skills that may be needed to manage a coffee shop, such as resource management [38], resources priorities and planning [37], and taking advantages of opportunities and reducing threats [13], such as planning for weather events.

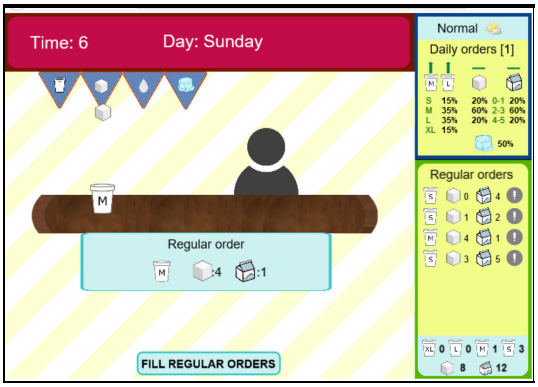

Figure 11. Subgame Weekend Barista for Organizaing and Planning.

VI. EVALUATION PLAN

The research team plans to broadly announce OMEGA through many different channels (e.g., within conferences, within universities, through social media platforms, etc.). The primary target audience of OMEGA are adults (e.g., university students, people in the workforce, etc.). There are two types of data that will be collected within the evaluation: (1) data from different existing valid and reliable questionnaires; (2) log information from OMEGA.

With the comparison between the data collected from existing valid and reliable questionnaires and the performance players have in OMEGA, the research can tell if a particular subgame is designed well to serve its purpose – measuring one's meta-cognitive skill – as well as verify if the continuously playing OMEGA could improve players' metacognitive skills.

In the evaluation plan approved[2] by the university's Research Ethics Board, OMEGA will be evaluated with respect to four issues. Each issue will be evaluated through a separate evaluation with different participants. There is no age limitation and target users on using OMEGA. The participants will be invited via different channels include conferences and workshops, colleagues at different universities, and social networks like Facebook.

The next subsections will give an overview into those four issues, describe the research questions for each of the four evaluation studies and explain the methods and procedures to answer those research questions.

1) Overview of evaluation studies

a) Effectiveness of subgames to improve meta-cognitive skills (Evaluation 1)

This research will include the evaluation of each subgame with respect to whether or not playing the subgame increases the respective meta-cognitive skill. Furthermore, this research will investigate how accurately OMEGA is identifying meta-cognitive skills of players. In addition, this research will include investigations into the relationship between the players' meta-cognitive skills and how they use, behave and perform in the game.

b) Usability of OMEGA (Evaluation 2)

This research will include the evaluation of the usability of OMEGA as well as investigations into the relationships between perceived usability, perceived enjoyment of the game, purpose for playing, how players use, behave and perform in OMEGA and demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games).

c) OMEGA Players' attitude towards computer games (Evaluation 3)

As players' attitude towards computer games may affect their usage of OMEGA, such difference may lead to the different results in terms of the effectiveness of OMEGA. This research will include investigations of the relationships between players' general attitude towards computer games, demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games) and how players use, behave and perform in OMEGA. Log information from OMEGA can help the research team to identify and group players' usage and behaviours in OMEGA.

d) Player's behavior, usage and performance in OMEGA (Evaluation 4)

Even players who have similar attitude towards computer games, their patterns of using OMEGA may affect the effectiveness of OMEGA. This research will include detailed investigations into data on how players use, behave and perform in OMEGA.

2) Research Questions

In this subsection, the research questions (RQs) of the four evaluation studies planned to be conducted are described.

a) Evaluation 1

- RQ1: How effective is each of the ten subgames in improving the associated meta-cognitive skill? [each subgame is associated with one meta-cognitive skill which it aims to improve]
- RQ2: How do the players' meta-cognitive skills identified in OMEGA relate to their meta-cognitive skills as identified through the questionnaires?
- RQ3: What is the relation between the players' meta-cognitive skills and how they use, behave and perform in the game?

b) Evaluation 2

- RQ4: What is the perceived usability of OMEGA?
- RQ5: Are there relationships between the perceived usability, perceived enjoyment of the game, purpose for playing, how players use,

[2] Ethics File No.: 23541

behave and perform in OMEGA and demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games)?

c) Evaluation 3

- RQ6: Are there relationships between players' attitude towards computer games, demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games) and how players use, behave and perform in OMEGA?

d) Evaluation 4

- RQ7: How are players using, behaving and performing in OMEGA?
- RQ8: What is the profile of typical players of OMEGA?

RQ1 investigates how effective OMEGA is in increasing players' metacognitive skills and RQ2 investigates whether meta-cognitive skills are correctly identified in OMEGA. RQ4 aims at investigating the perceived usability of OMEGA. The other research questions aim at investigating how players use OMEGA and who the typical players of OMEGA are (e.g., players' in a particular age group, with a particular gender, with a particular educational level, etc.). By knowing who the typical players are, the research team also knows for whom OMEGA is not that attractive yet and can work towards improving OMEGA to reach a wider audience.

3) Methods and Procedures

The research team has also designed and planned the following methods and procedures for each of the four evaluations.

a) Evaluation 1

For each of the ten subgames, 50 participants are sought who would go through the following steps:

- Step 1: Depending on the meta-cognitive skill that is targeted by the subgame (e.g., problem solving), a respective questionnaire (e.g., problem solving questionnaire) will be presented to be filled out.
- Step 2: Players are expected to play OMEGA and complete 50 matches.
- Step 3: After the 50th match, the same questionnaire as in step 1 will be presented to be filled out.

Participants will be invited to the evaluation right after they created an account in OMEGA. To answer RQ1 and RQ2, the results from the first and second questionnaire will be compared and brought in relation to the respective meta-cognitive skills identified by OMEGA. Statistical tests (e.g., t-test, u-test, correlation analysis) will be used for this analysis. To answer RQ3, statistical analysis will be conducted on the data about meta-cognitive skills and the log information.

b) Evaluation 2

In this evaluation, 50 participants will be asked to participate. Invitations to participate will only be sent out after a potential participant has completed 15 matches in OMEGA. In order to participate, participants only have to fill out the Usability Questionnaire. To answer RQ4, the results of the questionnaire will be summed up and average ratings will be built to get an understanding about the general perceived usability of OMEGA as well as its features and subgames. To answer RQ5, statistical analysis (e.g., t-tests, u-tests, correlation analysis, etc.) will be used to investigate relationships between the perceived usability, perceived enjoyment of the game, purpose for playing, how players use, behave and perform in OMEGA and demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games).

c) Evaluation 3

In this evaluation, 50 participants will be asked to participate. Invitations to participate will only be sent out after a potential participant has completed 2 matches in OMEGA. In order to participate, they only have to fill out the Attitude Questionnaire. To answer RQ6, statistical analysis (e.g., t-tests, u-tests, correlation analysis, etc.) will be used to investigate the relationships between players' attitude towards computer games, demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games) and how players use, behave and perform in OMEGA.

d) Evaluation 4

No active participation from players is required for this evaluation since this evaluation will be based on log information that has been already stored in OMEGA. To answer RQ7, statistical analysis (e.g., descriptive) will be used. To answer RQ8, statistical analysis as well as data mining algorithms will be used to find differences in how players use, behave and perform in OMEGA.

VII. CONCLUSION

There are many different emerging technologies that can enhance learning. One of them are educational games. Educational games have the potential to make learning more engaging because, unlike traditional media, games are interactive. Educational games present players with challenging problems to solve, which is what makes a game fun [11]. Learning is implicit from the feedback they receive about the actions they have taken, or choices they have made in the game [36].

Developing an educational game is not easy. One of the main research challenges in educational games is how to combine gaming aspects and learning aspects to create a game that is fun to play but also facilitates learning while learners play, preferable in a way that learners do not even notice that they are learning while they play. In this research, the research team aims at designing and developing the educational game OMEGA that fulfills this important objective, namely to help players increase their meta-cognitive skills while playing. Such improved skills will boost users' learning capacities, whether at university or on the job; will make further education easier; enable them to deliver high quality work; empower them to realize their full potential; and overall, make a stronger contribution to our economy. To the best of our knowledge, no educational game exists that focuses on

increasing players' meta-cognitive skills such as the ones OMEGA is focusing on. As such, OMEGA is a novel educational game that has high potential to improve people's lives.

The research team has designed and developed the game OMEGA that includes 10 subgames and each of them is designed carefully for a specific meta-cognitive skill according to the different elements identified in a detailed literature review. Moreover, a detailed and complete evaluation plan is ready and approved by research ethics board. The evaluations aim at finding out whether OMEGA is effective in improving players' meta-cognitive skills, how easy it is to use the game (perceived usability) and which types of players are attracted by the game (and which types of people are not attracted).

The results of the evaluations will be used to enhance OMEGA in terms of making it more effective in improving players' meta-cognitive skills, making it easier to use and making it attractive for a broader range of people. Participants of this research will benefit from such improvements. In addition, by improving OMEGA, more people can benefit from it in terms of being able to increase their meta-cognitive skills through playing. Given that OMEGA is the first educational game that targets to improve players' meta-cognitive skills, our findings will be a valuable contribution to the research community in game-based learning.

So far, OMEGA has been developed for desktop computers/laptops. Soon we will also start implementing a mobile version of OMEGA. This research will then also consider and include the evaluation of the usability of OMEGA's mobile version as well as investigations into the relationships between perceived usability, perceived enjoyment of the game, purpose for playing, how players use, behave and perform in the mobile version of OMEGA and demographic and gaming-related factors (i.e., gender, age, educational level, academic/job-related background, gamer type, preferred game genres, hours per week for playing computer games). In addition, a data-driven profile for players of the mobile version of OMEGA will be compared to the one for the desktop version. We expect to find interesting results from investigations into how users play OMEGA as well as the comparison between the desktop and mobile version of OMEGA.

REFERENCES

[1] American Institutes for Research, Just Write! Guide. U.S. Department of Education, 2012.

[2] B. S. Bloom, "The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring," Educational Researcher, 13(6), 1984, pp. 4-16.

[3] M. Chang, "Data Analytics for Education and Healthcare," in 2015 Proceedings of Science of Technology Innovation, Athabasca, AB, Canada: Faculty of Science and Technology, Athabasca University, pp. 73-91, 2015.

[4] C. Chang, M. Chang, and J.-S. Heh, "National Palace Museum Adventure - A Mobile Educational Role Playing Game for Museum Learning," in Ubiquitous Learning Environments and Technologies, Berlin: Springer, 2014, pp. 201-223.

[5] M. Chang and Kinshuk, "Web-based Multiplayer Online Role Playing Game (MORPG) for Assessing Students' Java Programming Knowledge and Skills," Proceedings of the 3rd IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning, (DIGITEL 2010), Kaohsiung, Taiwan, April 12-16, IEEE Press, 2010, pp. 103-107.

[6] M. Chang, D. Lachance, F. Lin, F. Al-Shamali, and N.-S. Chen, "Enhancing Orbital Physics Learning Performance through a Hands-on Kinect Game," Education and Science, 40(180), 2015, pp. 1-12, http://egitimvebilim.ted.org.tr/index.php/EB/article/view/3145

[7] S.-T. Chen, I.-T. Chiang, E. Z.-F. Liu, and M. Chang, "Effects of Improvement on Selective Attention: Developing Appropriate Somatosensory Video Game Interventions for Insititutional-dwelling Elderly with Disabilities," The Turkish Online Journal of Educational Technology, 11(4), 2012, pp. 409-417, http://eric.ed.gov/?id=EJ989306

[8] P. Chen, R. Kuo, M. Chang, and J.-S. Heh, "The Effectiveness of Using In-Game Cards as Reward," Research and Practice in Technology Enhanced Learning, 12, 2017, Article #15, https://telrp.springeropen.com/articles/10.1186/s41039-017-0054-8

[9] O. Chuvgunova and S. Kostromina, "Planning as a learning skill of students," Procedia - Social and Behavioral Sciences, 217, 2016, pp. 132-138.

[10] V. Garrels, "Goal setting and planning for Norwegian students with and without intellectual disabilities: Wishing upon a star?" European Journal of Special Needs Education, 32(4), 2017, pp. 493-507, doi:10.1080/08856257.2016.1261487

[11] J. P. Gee, Good Video Games + Good Learning, 2nd ed., New York: Peter Lang Publishing, 2013.

[12] D. Z. Hambrick, "Brain Training Doesn't Make You Smarter," Scientific American, 2014, https://www.scientificamerican.com/article/brain-training-doesn-t-make-you-smarter/?print=true

[13] B. Hawamdeh and Z. Alhawamdeh, "The degree of possessing strategic planning skills among academic leaderships at the Jordanian private universities," European Scientific Journal, 8(13), 2012, https://eujournal.org/index.php/esj/article/view/193

[14] D. H. Jonassen, "Toward a Design Theory of Problem Solving," Educational Technology Research And Development, 48(4), 2000, pp. 63-85.

[15] D. A. Jones, M. Chang, and Kinshuk, "Pecunia - A Life Simulation Game for Finance Education," Research and Practice in Technology Enhanced Learning, 9(1), 2014, pp. 7-39.

[16] S. Khezrlou, "The Relationship between Cognitive and Metacognitive Strategies, Age, and Level of Education," The Reading Matrix, 12(1), 2012, pp. 50-61.

[17] R. Kuo, M. Chang, Kinshuk, and E. Z.-F. Liu, "Applying Multiplayer Online Game in Actionscript Programming Courses for Students Doing Self-Assessment," Proceedings of Workshop on New Paradigms in Learning: Robotics, Playful Learning, and Digital Arts, in the 18th International Conference on Computers in Education, (ICCE 2010), Putrajaya, Malaysia, November 29-December 3, APSCE Press, 2010, pp. 351-355.

[18] R. Kuo, M. Chang, C.-W. Lyu, and J.-S. Heh, "A Pilot Study of the Situated Game for Autistic Children Learning Activities of Daily Living," Research and Practice in Technology Enhanced Learning, 8(2), 2013, pp. 291-315.

[19] O. Kwon and D. Jung, "An association model based reasoning method for Individualized service recommender," Expert Systems, 30(1), 2013, pp. 54-65.

[20] C. Larkin, R. Valand, P. Syrysko, R. Harris, D. Shaw, M. Brown, J. Pinchin, K. Benning, S. Sharples, and J. Blakey, "'Night Shift': A Task Simulation to Improve On-Call Prioritisation, Self-Management, Communication, and Route Planning Skills," Proceedings of International Conference on Interactive Technologies and Games, October 16-17, IEEE Press, 2014, pp. 59-62, doi:10.1109/iTAG.2014.11

[21] T. Lin, Kinshuk, S. Graf, "Cognitive Trait Model and Divergent Associative Learning," Proceedings of the 7th IEEE International Conference on Advanced Learning Technologies (ICALT 2007), July 18-20, IEEE Press, 2007, pp. 325-327.

[22] C.-H., Lin, E. Z.-F. Liu, Y.-L. Chen, P.-Y. Liou, M. Chang, C.-H. Wu, and S.-M. Yuan, "Game-Based Remedial Instruction in Mastery Learning for Upper-Primary School Students," Educational Technology & Society, 16(2), 2013, pp. 271-281, https://www.j-ets.net/ETS/journals/16_2/22.pdf

[23] J. Littlemore, "The relationship between associative thinking, analogical reasoning, image formation and metaphoric extension strategies," In Confronting Metaphor in Use: An applied linguistic approach, M. Zanotto, L. Cameron, M. Cavalcanti, Eds. John Benjamins Publishing Company, 2008, pp.199-222.

[24] C. Lu, M. Chang, Kinshuk, E. Huang, and C.-W. Chen, "Context-aware Mobile Role Playing Game for Learning," in The New Developments in Technology Enhanced Learning, Berlin: Springer, 2014, pp. 131-146.

[25] C. Lu, M. Chang, Kinshuk, E. Huang, and C.-W. Chen, "Story Decorated Context-Aware Mobile Educational Game - A Case of Canada and Taiwan," Educational Technology & Society, 17(2), 2014, pp. 101-114, https://www.j-ets.net/ETS/journals/17_2/9.pdf

[26] Max Planck Institute for Human Development and Stanford Center on Longevity, A Consensus on the Brain Training Industry from the Scientific Community, 2014, http://longevity3.stanford.edu/blog/2014/10/15/the-consensus-on-the-brain-training-industry-from-the-scientific-community/

[27] D. Munro, J. Stuckey, C. MacLaine, Skills—Where Are We Today? Ottawa: The Conference Board of Canada, 2014.

[28] U. Priss, Associative and Formal Concepts," Proceedings of International Conference on Conceptual Structures: Integration and Interfaces (ICCS 2002), July 15-19, Berlin: Springer, 2002, pp. 354-368, http://www.upriss.org.uk/papers/iccs02.pdf

[29] C. Ricketts, J. Brice, and L. Coombes, "Are multiple choice test fair to medical students with specific learning disabilities?" Advances in Health Sciences Education, 15(2), 2010, pp. 265-275.

[30] D. Ruggiero and L. Green, "Problem solving through digital game design: A quantitative content analysis," Computers in Human Behavior, 73, 2017, pp. 28-37.

[31] Y. Safari and H. Meskini, "The Effect of Metacognitive Instruction on Problem Solving Skills in Iranian Students of Health Sciences," Global Journal of Health Science, 8(1), 2016, pp. 150-156. http://www.ccsenet.org/journal/index.php/gjhs/article/view/444224

[32] J. X. Seaton, S. Graf, and M. Chang, "Integrating a Learning Analytics Dashboard in an Online Educational Game," In Data Analytics Approaches in Educational Games and Gamification Systems (Chapter 7), A. Tlili and M. Chang, Eds. Singapore: Springer, 2019, in-press.

[33] J. X. Seaton, S. Graf, M. Chang, and A. Farahmand. (2018). "Incorporating Learning Analytics in an Educational Game to Provide Players with Information about how to Improve their Performance," Proceedings of 18th IEEE International Conference on Advanced Learning Technology (ICALT 2018), Mumbai, India, July 9-13, IEEE Press, 2018, pp. 229-230.

[34] M. Shubik, "It Is Not Just a Game!" Simulation & Gaming, 40(5), 2009, pp. 587-601.

[35] S. Sloman, "The empirical case for two systems of reasoning," Psychological Bulletin, 119(1), 1996, pp. 3-22, https://psycnet.apa.org/doi/10.1037/0033-2909.119.1.3

[36] M. Song and S. Zhang, "EFM: A Model for Educational Game Design. In Technologies for E-Learning and Digital Entertainment," Lecture Notes in Computer Science, vol 5093, Berlin: Springer, 2008, pp. 509-517

[37] University of Nottingham, (July, 2016), Planning, organising and flexibility. Retrieve, September/October, https://www.nottingham.ac.uk/hr/guidesandsupport/performanceatwork/pdpr/pdpr-behavioural-competency-guide/personal-effectiveness/planning,-organising-and-flexibility.aspx

[38] University of Strathclyde, (n.d), Planning & Organising Skills, https://www.strath.ac.uk/professionalservices/careers/skills/generalskills/planningorganisingskills/

[39] S. G. Vandenberg and A. R. Kuse, "Mental Rotations, a Group Test of Three-Dimensional Spatial Visualization," Perceptual and Motor Skills, 47(2), 1978, pp. 599-604. https://doi.org/10.2466/pms.1978.47.2.599.

[40] A. I. Wang, "The wear out effect of a game-based student response system," Computers & Education, 82, 2015, pp. 217-227, https://doi.org/10.1016/j.compedu.2014.11.004

[41] P. Wouters, C. van Nimwegen, H. van Oostendorp, and E. D. van der Spek, "A meta-analysis of the cognitive and motivational effects of serious games," Journal of Educational Psychology, 105(2), 2013, pp. 249-265, http://dx.doi.org/10.1037/a0031311

[42] Organisation for Economic Co-operation and Development (OECD). Social and Emotional Skills - Well-being, connectedness and success. Access: http://www.oecd.org/education/ceri/social-emotional-skills-study