Digital Game-Based Support for Learning The Phlebotomy Procedure

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Practice-based training in education is important, expensive, and resource-demanding. Digital games can provide complementary training opportunities for practicing procedural skills and increase the value of the limited laboratory training time in biomedical laboratory science (BLS) education. The Digital Game-Based Learning (DGBL) application has been taken as an engaging and effective learning method for learning how to perform the phlebotomy procedure, and even—for some students—to reduce phlebotomy-related anxiety. The game motivated students to train more, and teachers were positive towards using it in education.

Keywords: Digital Game-Based Learning (DGBL) ; phlebotomy ; blood sampling

1. Introduction

Digital Game-Based Learning (DGBL) has gained increased interest for learning and training in higher education for its potential benefits such as increasing engagement and allowing self-paced learning, automated feedback, and solutions for flipped classrooms [1][2].

There are several educational programs, e.g., biomedical laboratory science (BLS) and other health-care educations, where practical learning is essential [3][4][5]. For the phlebotomy (venous blood sampling) procedure, students need practical training to achieve the necessary knowledge and skills for their future work. It is an important skill to learn for several professions, while also being a heavily resource-constrained learning activity experiencing challenges in planning sufficient phlebotomy training sessions in the laboratories. Most of the errors regarding blood analysis stem from simple pre-analytic mistakes such as incorrect handling of sample tubes, misidentification of patients, and mislabeling of samples [6][7]. Therefore, it is important to explore new ways of allowing students more training opportunities for procedural and skills knowledge for the phlebotomy procedure. While DGBLs have promising benefits in this regard, implementing the games can also present challenges, such as knowing how to implement these effectively, use the underlying technology, meet requirements from the educational system, obtain suitable games [8] from the teachers, or handle the lack of engagement from the students' perspective.

While an important aspect of learning to perform phlebotomy correctly is skill-based, this cannot be achieved without understanding the whole process surrounding the main activities [9]. An earlier/better understanding of necessary procedural elements can help the students to reach higher levels of skill acquisition [10]. By helping the students experience how all parts of the procedure relate to each other, DGBL can be a valuable tool for providing opportunities for meaningful learning [11][12]. When considering game design it can be valuable to differentiate skill-based learning from procedural learning, as it affects the design elements to be chosen and the scope of the game..

Defining supportive games is challenging as there are many choices associated with the development of digital game applications, e.g., technologies and techniques [13], and adaptivity [14]. Many previously developed games are not in use. To ensure that the games are actually used in education necessitates integration, not only to existing laboratory facilities and other technologies but also to actual learning goals [15]. Such mapping of game elements to the learning goals can be difficult [16][17]. The StikkApp project investigates how to develop a 2D game supporting learning the phlebotomy process [18][19] and how to successfully integrate it into education. Through this game, students can train at their own pace and prepare for real-life laboratory exercises and learn from automated feedback provided by the game. They can play through different phlebotomy scenarios to familiarize themselves with the procedures and learn-by-doing.

2. Challenges for Learning Phlebotomy

Following a correct blood sampling procedure is crucial in order to ensure that the quality of the biological specimens are satisfactory [20][21][22][23]. Phlebotomy (venous blood sampling) is undertaken by BLS health care professionals, nurses and other health professionals. Hence, practicing the blood sampling procedure is widely important. Traditionally, students receive little training and few opportunities to practice the phlebotomy procedure, and if they are working at smaller diagnostic clinics, they can not necessarily practice it often enough. Currently, teaching phlebotomy in health care education encounters several challenges, such as limited time, access to necessary resources, or laboratory facilities. Additionally, a major challenge is to reproduce the conditions (or elements of the conditions) of an authentic working environment at campuses [18][24][25][26]. Variations between laboratory environments makes it necessary for BLS professionals and nurses to learn to perform the procedure independently of the location or the tradition at workplaces. Some nurses or BLS students learn only in the laboratories at their institutions. Performing phlebotomy at various locations may increase the confidence of students when performing the procedure. Without utilizing digital technology, practice-based training at multiple places is seldom achievable for many students.

The education of health professions is constantly changing, depending on new requirements from today's complex society. Researchers need to focus more on distance education [27], and utilization of supportive technologies such as serious games, gamification, virtual reality, and virtual simulation, here used under the overarching term of Digital Game-Based Learning (DGBL). All these new technologies contribute to DGBL with the overall vision to support practice-based learning [28][29].

While a vast number of different supportive technologies exist, few solutions are actively used in classrooms and considered adequate to help reach learning goals, except computers and mobile phones. While there are several evaluations addressing the effectiveness of some specific digital tools, these are often feasibility studies in research laboratories and are seldomly implemented in a real usage context [15]. The implementation of such new technologies as virtual reality, serious games, or mixed reality technologies can be complex, especially for situations where both the users and stakeholders responsible for use do not have the technical competence necessary to adjust the technologies to the usage context [30].

3. Tools Supporting Phlebotomy Learning

Different strategies are applied when BLS students are taught the phlebotomy procedure. Lectures are used to introduce concepts and explain the different steps of the phlebotomy procedure. Students are also given written and illustrated explanations of the procedure with supplementary information for all steps in the procedure. Demonstrations are given both physically, and as videos demonstrating all the steps in the procedure. After students have heard about, read about, and seen the procedure, they start to practice performing venous blood sampling on each other in the school laboratory. The course instructors rotate through students, supervising them and giving them continuous feedback on their performance. Some students are also offered use of a mannequin arm for practicing, without supervision, necessitating the students to self-assess. When students can repeatedly perform the procedure, a routine can be established, and their self-confidence can increase. However, the number of times the students can perform the venipuncture on each other is limited, which restricts the number of repetitions in realistic conditions.

There are currently a variety of different serious games and virtual simulations for phlebotomy learning:

StikkApp is a serious game for mobiles and PCs[19]. The game provides opportunities for students to play through the phlebotomy procedure and learn aspects such as how to read a requisition form, which blood tubes and other equipment to use, the order of actions and more. At the end of the play session they get a score for their total performance and for each section, which can help find areas of improvement and provide motivation.

Prøvetakingsmesteren is a Norwegian phlebotomy learning game that is a part of the "Attensi Skills" mobile application [31]. It features several categories to "master". In the game, virtual avatars can interact with users. It is primarily focused on assessing the knowledge of a user that has already been through the material and estimate what they learnt. The gameplay is similar to other games in the "Attensi Skills" application, and supports goal achievement with gamification elements such as quizzes, finding the right combination of words, etc.

Labster is a learning game for PC [32]. It contains an assortment of learning scenarios for different domains of science, including some modules where the player analyses blood samples. It does not contain elements regarding the blood sampling procedure itself.

360-Phlebotomy is a Virtual Reality (VR) serious game utilizing 360°-images and -videos of real hospitals and laboratories to create authentic learning environments [33]. By using 360°-footage there is a trade-off between visual realism and movement, but changing the context may contribute to learning, not only the phlebotomy procedures, but also differences in environments for blood sampling.

VIDA-Nursing is a VR simulation for learning vacuum blood collection on adults [34]. It uses hand-tracking as the primary input mechanic.

Laerdal Virtual Phlebotomy is a discontinued product from Laerdal Medical [35]. It contains a haptic input device that connects to a PC and is intended to be used with a 2D screen. Studies have shown an improvement in completion time and error score by performing training in this way [36].

CathSim is a non-immersive VR simulator used for training needle stick procedures such as IV cannulation and phlebotomy [37]. It consists of a dedicated haptic input device that mimics the force resistance when puncturing a vein and connects to a PC to provide supporting visuals and performance data.

Certainly, there can be several other different tools supporting phlebotomy learning. Many of these tools can be beneficial for a particular application area, while there are others for some others. For non-experts, it can be difficult to navigate and choose between the tools. Developing their own applications is also an approach that universities utilize. These can have their benefits, since universities can steer the design and development of the tools, and these can be more flexible, but they are often limited compared to solutions offered by professional companies who often have multiple customers as sources of funding.

References

1. Tsai, Y.-L.; Tsai, C.-C. A Meta-Analysis of Research on Digital Game-Based Science Learning. J. Comput. Assist. Lear n. 2020, 36, 280–294.
2. Policy Document: The Norwegian Institute of Biomedical Science: Future Trends in Biomedical Laboratory Science: A N orwegian Perspective. Available online: https://www.nito.no/fagmiljo/bioingeniorfaglig-institutt/brosjyrer-og-dokumenter/i n-english/ (accessed on 26 February 2022).
3. Linsenmeier, R.A.; Saterbak, A. Fifty Years of Biomedical Engineering Undergraduate Education. Ann. Biomed. Eng. 20 20, 48, 1590–1615.
4. Markowski, M.; Bower, H.; Essex, R.; Yearley, C. Peer Learning and Collaborative Placement Models in Health Care: A Systematic Review and Qualitative Synthesis of the Literature. J. Clin. Nurs. 2021, 30, 1519–1541.
5. Pitkänen, S.; Kääriäinen, M.; Oikarainen, A.; Tuomikoski, A.-M.; Elo, S.; Ruotsalainen, H.; Saarikoski, M.; Kärsämänoja, T.; Mikkonen, K. Healthcare Students' Evaluation of the Clinical Learning Environment and Supervision—A Cross-Secti onal Study. Nurse Educ. Today 2018, 62, 143–149.
6. Plebani, M. Errors in Clinical Laboratories or Errors in Laboratory Medicine? Clin. Chem. Lab. Med. 2006, 44, 750–759.
7. Zehra, N.; Malik, A.H.; Arshad, Q.; Sarwar, S.; Aslam, S. Assessment of Preanalytical Blood Sampling Errors in Clinical Settings. J. Ayub Med. Coll. Abbottabad 2016, 28, 267–270.
8. Watson, W.; Yang, S. Games in Schools: Teachers' Perceptions of Barriers to Game-Based Learning. J. Interact. Lear n. Res. 2016, 27, 153–170.
9. White, J.A.; Gaver, D.P.; Butera, R.J.; Choi, B.; Dunlop, M.J.; Grande-Allen, K.J.; Grosberg, A.; Hitchcock, R.W.; Huang -Saad, A.Y.; Kotche, M.; et al. Core Competencies for Undergraduates in Bioengineering and Biomedical Engineering: Findings, Consequences, and Recommendations. Ann. Biomed. Eng. 2020, 48, 905–912.
10. Dreyfus, H.; Dreyfus, S. Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer; T he Free Press: New York, NY, USA, 1987; ISBN 10.
11. Mayer, R.E. Rote Versus Meaningful Learning. Theory Pract. 2002, 41, 226–232.
12. Mystakidis, S. Deep Meaningful Learning. Encyclopedia 2021, 1, 988–997.
13. Kenwright, B. Game-Based Learning in Higher Education. Available online: https://xbdev.net/misc_demos/demos/game _based_learning/paper.pdf (accessed on 26 February 2022).
14. Liu, Z.; Moon, J.; Kim, B.; Dai, C.-P. Integrating adaptivity in educational games: A combined bibliometric analysis and meta-analysis review. Educ. Technol. Res. Dev. 2020, 68, 1931–1959.

15. Vlachopoulos, D.; Makri, A. The Effect of Games and Simulations on Higher Education: A Systematic Literature Review. Int. J. Educ. Technol. High. Educ. 2017, 14, 22.

16. Proulx, J.-N.; Romero, M.; Arnab, S. Learning Mechanics and Game Mechanics Under the Perspective of Self-Determination Theory to Foster Motivation in Digital Game Based Learning. Simul. Gaming 2017, 48, 81–97.

17. Arnab, S.; Lim, T.; Brandao Carvalho, M.; Bellotti, F.; De Freitas, S.; Louchart, S.; Suttie, N.; Berta, R.; De Gloria, A. Mapping Learning and Game Mechanics for Serious Games Analysis. Br. J. Educ. Technol. 2015, 46, 391–411.

18. Frøland, T.H.; Heldal, I.; Sjøholt, G.; Ersvær, E. Games on Mobiles via Web or Virtual Reality Technologies: How to Support Learning for Biomedical Laboratory Science Education. Information 2020, 11, 195.

19. Tord Hettervik Frøland; Ilona Heldal; Turid Aarhus Braseth; Irene Nygård; Gry Sjøholt; Elisabeth Ersvær; Digital Game-Based Support for Learning the Phlebotomy Procedure in the Biomedical Laboratory Scientist Education. *Computers* **2022**, *11*, 59, 10.3390/computers11050059.

20. World Health Organization. WHO Guidelines on Drawing Blood: Best Practices in Phlebotomy; World Health Organization: Geneva, Switzerland, 2010.

21. Saleem, S.; Mani, V.; Chadwick, M.A.; Creanor, S.; Ayling, R.M. A Prospective Study of Causes of Haemolysis during Venepuncture: Tourniquet Time Should Be Kept to a Minimum. Ann. Clin. Biochem. 2009, 46, 244–246.

22. Makhumula-Nkhoma, N.; Weston, K.L.; McSherry, R.; Atkinson, G. The Impact of Venepuncture Training on the Reduction of Pre-Analytical Blood Sample Haemolysis Rates: A Systematic Review. J. Clin. Nurs. 2019, 28, 4166–4176.

23. Lima-Oliveira, G.; Brennan-Bourdon, L.M.; Varela, B.; Arredondo, M.E.; Aranda, E.; Flores, S.; Ochoa, P. Clot Activators and Anticoagulant Additives for Blood Collection. A Critical Review on Behalf of COLABIOCLI WG-PRE-LATAM. Crit. Rev. Clin. Lab. Sci. 2021, 58, 207–224.

24. Frøland, T.H.; Ersvar, E.; Sjeholt, G.; Heldal, I.; Freyen, A.H.; Logeswaran, S.; Kovari, A.; Katona, J.; Costescu, C.; Rosan, A.; et al. MStikk—A Mobile Application for Learning Phlebotomy. In Proceedings of the 2019 10th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Naples, Italy, 23–25 October 2019; pp. 499–506.

25. Frøland, T.H.; Heldal, I.; Ersvar, E.; Sjoholt, G.; Kovari, A. WStikk—Web-Based Phlebotomy Learning. In Proceedings of the 2019 E-Health and Bioengineering Conference (EHB), Iasi, Romania, 21–23 November 2019; pp. 1–4.

26. Souza Júnior, V.; Mendes, I.; Alves, L.; Jackman, D.; Wilson-Keates, B.; Godoy, S. Peripheral Venipuncture Education Strategies for Nursing Students: An Integrative Literature Review. J. Infus. Nurs. Off. Publ. Infus. Nurses Soc. 2020, 43, 24–32.

27. Flores, D.D.; Bocage, C.; Devlin, S.; Miller, M.; Savarino, A.; Lipman, T.H. When Community Immersion Becomes Distance Learning: Lessons Learned From a Disrupted Semester. Pedagog. Health Promot. 2021, 7, 46–50.

28. Van Eck, R. Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless. Available online: https://er.educause.edu/articles/2006/1/digital-gamebased-learning-its-not-just-the-digital-natives-who-are-restless (accessed on 21 February 2022).

29. Backlund, P.; Hendrix, M. Educational Games—Are They Worth the Effort? A Literature Survey of the Effectiveness of Serious Games. In Proceedings of the 2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES), Poole, UK, 11–13 September 2013; pp. 1–8.

30. Kaplan, A.D.; Cruit, J.; Endsley, M.; Beers, S.M.; Sawyer, B.D.; Hancock, P.A. The Effects of Virtual Reality, Augmented Reality, and Mixed Reality as Training Enhancement Methods: A Meta-Analysis. Hum Factors 2021, 63, 706–726.

31. Prøvetakingsmesteren. Available online: https://www.furst.no/om-furst/kundekommunikasjon/provetakingsmesteren/ (accessed on 1 March 2021).

32. Labster|200+ Virtual Labs for Universities and High Schools. Available online: https://www.labster.com/ (accessed on 30 June 2021).

33. Frøland, T.H.; Ilona, H.; Sjøholt, G.; Ersvær, E. Merging 360°-Videos and Game-Based Virtual Environments for Phlebotomy Training: Teachers and Students View. In Proceedings of the 2021 International Conference on e-Health and Bioengineering (EHB), Iasi, Romania, 18–19 November 2021.

34. Souza-Junior, V.D.D.; Mendes, I.A.C.; Tori, R.; Marques, L.P.; Mashuda, F.K.K.; Hirano, L.A.F.; Godoy, S.D. VIDA-Nursing v1.0: Immersive Virtual Reality in Vacuum Blood Collection among Adults. Rev. Lat. Am. Enferm. 2020, 28, e3263.

35. Virtual Phlebotomy (Discontinued). Available online: https://laerdal.com/us/products/skills-proficiency/venous-arterial-access/virtual-phlebotomy/ (accessed on 17 February 2022).

36. Loukas, C.; Nikiteas, N.; Kanakis, M.; Georgiou, E. Evaluating the Effectiveness of Virtual Reality Simulation Training in Intravenous Cannulation. Simul. Healthc. 2011, 6, 213–217.

37. Scerbo, M.W.; Bliss, J.P.; Schmidt, E.A.; Thompson, S.N. The Efficacy of a Medical Virtual Reality Simulator for Trainin g Phlebotomy. Hum. Factors 2006, 48, 72–84.