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A Review of Past Studies: Connecting Google Classroom Learning Activities with Digital & Information Literacy Linked to Bloom's Taxonomy of Educational Objectives

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Abstract: This study reports a review of past studies focusing on measuring the effectiveness of online learning activities conducted using the Google Classroom platform in achieving learning objectives. Past studies have provided useful and practical information on the effectiveness and user satisfaction of using Google Classroom. This study extends the understanding on the applicability of the use of Google Classroom as a platform for teaching and learning. Past studies were reviewed assessing the extent activities conducted via Google Classroom in achieving digital literacy linked to Bloom's Taxonomy of Educational Objectives in the context of science, technology, engineering and mathematics (STEM) and non-STEM learning. The achievement of STEM literacy through the learning activities on Google Classroom poses significant findings by reflecting on Bloom's Taxonomy of Educational Objectives. This study informs stakeholders in education industry on the practical applications and areas for improvement in promoting the uptake intentions of e-learning among the educators; achieving the aspiration of Education 4.0.

Keywords: Google Classroom, learning activities, STEM, Bloom's Taxonomy of Educational Objectives

1. Introduction

According to Bloem et al. (2014), the world is currently at the beginning point of the fourth stage of industrial development - Industrial Revolution 4.0, characterized by the so-called "Cyber-Physical Systems" (CPS). As a consequence of the ever-changing characteristics of technology, online spaces are rapidly emerging and evolving, while increasing in the overall number of users. Online spaces significantly impact how and why people learn nowadays (Gerber et al., 2016). However, as the cyber-physical world is emerging, there is a recurring issue among educators, parents and governments - concerning ways of preparing our current and future generations to thrive and succeed in this fast-changing world. Graham (2017) stated that it is beyond any doubt that education is the key of preparing our generations for the rapid development of information technology. Therefore, this paper sets out to review past studies and link the learning activities that had been carried out on a topical online learning platform, Google Classroom to Bloom's Taxonomy of Educational Objectives in the context of science, technology, engineering and mathematics (STEM) and non-STEM learning.

1.1 Google Classroom in Education 4.0

Education 4.0 has been described as integrating technology in the context of teaching and learning (Dunwill, 2016). G Suite for Education (formerly known as Google Apps for Education) launched the free accessible Google Classroom (GC) in 2014, making it an ideal online learning platform for developing countries (Azhar & Iqbal, 2018). Since then, educators around the globe have been exploring GC for almost seven years, endeavoring for the enrichment of 21st century teaching and learning experience. Furthermore, as compared with other Learning Management Software (LMS) like Moodle,

Blackboard and Edmodo, the nature of GC as a free cloud-based learning platform - its convenience and suitability to perform mobile learning have also improved the uptake intentions of the users in recent years (Kumar & Bervell, 2019). Most educators found that GC is time-saving, easy to use and communicate with (Liu & Chuang, 2016; Martínez-Monés et al. 2017), due to its interface which incorporates many other useful Google applications, such as Google Documents, Google Slides and Google Calendar. Salmon (2019) mentioned that learners who experience Education 4.0 will wish to be equipped with skills to face the challenges of their future careers and new world of work. Therefore, it is extremely necessary for educators to use platforms like GC, to fulfill the aspirations of Education 4.0.

1.2 Digital and Information Literacy Linked to Bloom's Taxonomy of Educational Objectives

Educational technologies have been developed from learning theories, combined with the design of digital learning activities (Beetham, 2013). The learning outcomes, on the other hand, can be interpreted in different levels of attainment and grades, such as through Bloom et al. (1956). The association between learning outcomes with relevant taxonomies provides the ability to independently evaluate the outcomes concerning knowledge, abilities and values (Beetham, 2013). In this context, these distinctions provide a valuable check on designing online learning activities, by assessing their educational objectives and level of learning experience. A certain level of digital and information literacy will be needed in achieving the goals of the online learning activities. There are six levels of educational objectives in Bloom's revised taxonomy with their respective cognitive processes work with knowledge – remember, understand, apply, analyze, evaluate and create. The six categories of objectives were arranged in a cumulative hierarchy; as achieving the next more complex skill or ability involves the prior achievement (Anderson et al., 2001). For more detailed information on the original and the revised Bloom's Taxonomy, the study by Krathwohl (2001) can be referred.

1.3 Reflecting STEM Literacy through Bloom's Taxonomy of Educational Objectives

Nowadays, science, technology, engineering and mathematics (STEM) learning has a wider definition to take in environment, economics, and medicine (Zollman, 2012). As we are in the generation that STEM literacy is required to become productive and knowledgeable citizens; however, there is no particular agreement in education that define STEM literacy (Zollman, 2012). According to the previous researcher, STEM literacy should not be viewed as a content field but should be as an integrative means, consisting of skills, abilities, factual information, procedures, concepts and metacognitive capacities to gain further learning. It has also been clarified by Zollman (2012) that Bloom's Taxonomy of Educational Objectives (1956) is a better approach in reflecting the synergy of strands in STEM literacy. Fisher (2009) also proposed a renewed interest in Bloom's Taxonomy – Bloom's Digital Taxonomy, which advances an extension on students' access to knowledge on online learning platforms. It is undeniable that the need to evolve from learning for STEM literacy to using STEM literacy for digital learning in order to satisfy our societal, economical and personal needs is really inevitable, and it is also in line with the aim to achieve the aspirations of Education 4.0.

1.4 The Present Study

Although there are studies on the effectiveness and satisfaction on GC in enhancing online learning experiences among the students, there is no comprehensive picture of how the learning activities on GC can be connected to the achievement of educational objectives. It is vital that the educators must thoughtfully design online learning activities, in order to maximize the effectiveness of the activities and to enrich the online learning experience of the learners. Therefore, this study provides a review of past studies by connecting the learning activities carried out on GC to the digital literacy linked to Bloom's Taxonomy of Educational Objectives in the context of STEM and non-STEM learning.

As Cropanzano (2009) described, theory papers can be more interesting when they "underscore commonalities that build coherence" (p. 1306). By connecting the learning activities on GC to the educational objectives, this study can provide new insights on the perceived benefits and also limitations

of GC that can be further improved in the future. It is undeniable that the uptake of online learning among educators around the globe is escalating, especially during the closedown of schools worldwide due to COVID-19 pandemic. Therefore, this study provides a better understanding of the effectiveness of GC and the perceived benefits of adopting it.

2. Method

2.1 Searching

The federated search service provided by Universiti Tunku Abdul Rahman (UTAR) was used. It includes a wide range of prominent educational and social science databases, such as ERIC, Emerald Insight and Elsevier. Besides, Google Scholar and Research Gate were also used as external resources. Snowballing method was adopted to select the relevant studies. The following terms or combinations of terms were assessed via advanced search using Boolean search technique: Title contains *Google Classroom* AND *learning activities* OR *activity* OR *learning tasks* OR *task* AND field contains *higher education* OR *undergraduate* OR *tertiary education.* The research studies selected were not restricted to Malaysian context; research studies from other countries were also taken into consideration, with the publication year from 2016 until 2020. In addition, the material type selected was articles with English as the language of the studies. As can be seen in Figure 1, in total, 229 articles were found at the initial stage.

2.2 *Selection*

The articles found were further selected based on these criteria: (i) the study reports on students learning; (ii) the study was conducted in higher education settings; (iii) the study provides empirical data; (iv) the study's primary focus was on the effectiveness of GC, not only on the psychological perceptions of GC users. Therefore, the following forms of research studies were rejected: (i) meta-analyses reports; (ii) studies that did not focus on students learning; (iii) studies conducted in primary and secondary school settings (iv) studies which focused only on the psychological perceptions of the GC users. In addition, after excluding materials such as unpublished theses and conference papers, a total of seven articles were selected for review.

2.3 Analysis

Based on the hierarchy of Bloom's taxonomy, the learning activities included in the studies reviewed have been classified into six categories - remember, understand, apply, analyze, evaluate and create. The contents of the selected articles were analyzed and summarized. The analysis includes the subject involved (STEM-related or non-STEM-related), research design, major findings of the research and the linking of learning activities to Bloom's Taxonomy of Educational Objectives.

3. Results

It has been found that almost all of the selected studies involved GC learning activities require the skills and ability to analyze and evaluate among the learners (See Table 1). As the skills in Bloom's Taxonomy are arranged in a cumulative hierarchy (Anderson et al., 2001); achieving the skills of analyzing and evaluating involves the prior achievement of skills of remembering, understanding and pplying. The ability to analyze and evaluate. The ability to analyze and evaluate are mostly required for the completion of learning activities such as reviewing information, answering questionnaires and tests that had been assigned on GC, carrying out online discussion, giving feedback by posting directly to the flow of discussions, creating mind maps through Google Draw, reflecting upon own learning through

GC's questioning capabilities, reacting to remarks, tracking and viewing their own progress in the learner's portal and performing collaborative learning and peer tutoring. On the other hand, the skill and ability to create had been required for learning activities such as sharing of materials and contribute to resources through Google Slides, making certain illustrations on certain topics and doing individual or group projects.

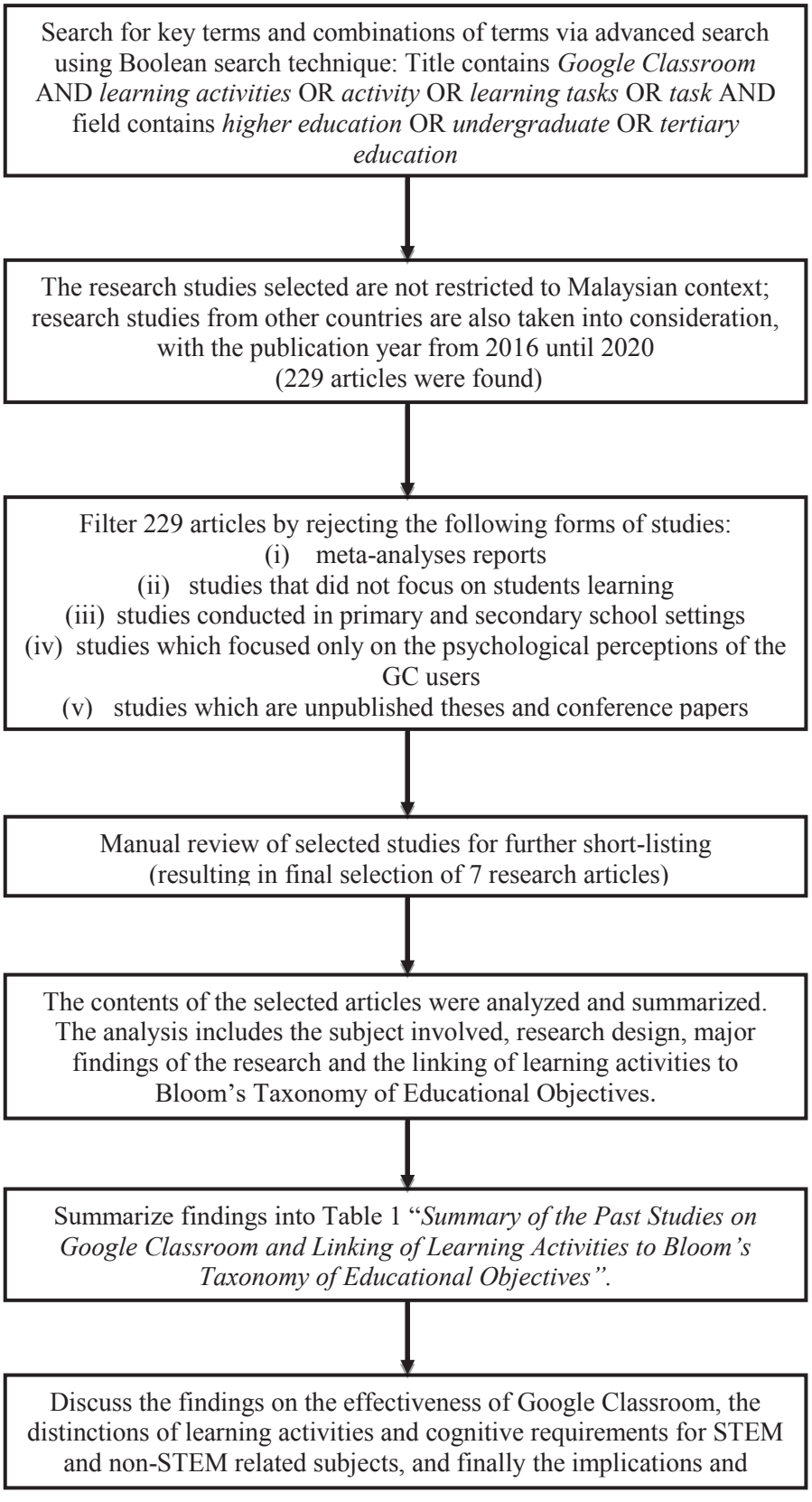

Figure 1. Methodological process for meta-analysis of past studies.

Table 1. *Summary of the Past Studies on Google Classroom and Linking of Learning Activities to Bloom's Taxonomy of Educ*

Research	Subject	Research design	Linking of learning activities to Bloom's taxonomy	Major findings
Shaharanee et al. (2016), Malaysia	Data mining subject under the Decision Sciences programme (STEM-related)	Quantitative design: Questionnaire	**Analyze**: Making observations, post questions **Evaluate:** Examine information, review what is already known using tools (computer software) to analyze the data and interpret data **Evaluate**: Propose answers and predictions; communicating results	Overall students are satisfied with Google Classroom thus showing it is effective as an active learning tool.
Dash (2019), India	Biochemistry (STEM-related)	Quantitative design: Questionnaire	**Create (Evaluate, Analyze, Apply, Understand, Remember):** Make certain illustrations on the topic of acid–base balance and upload the images on Google classroom	Learners reported to have better access to learning material and supplementary teaching resources, helpfulness of immediate feedback, and learning outside of the class environment. Preference of mobile phone over laptop to access Google Classroom was reported. Medical schools using e-learning employ blended learning as the most common computer assisted technology, and in that regard, Google Classroom can assist in enhancing faculty effectiveness and efficiency.
Basher	Different	Quantitative	**Evaluate** (Analyze, Apply,	There are significant statistical

(2017), Saudi Arabia	subjects for pre-service teachers (Non-STEM-related)	design: Experimental	Understand, Remember): Answer questionnaires and tests that had been assigned on GC *Unjustifiable: Publish assignments and homework on GC	differences in the results between the experimental and controlled group when the Google classroom application applied, on teaching efficiency of educational college students in each of its levels (planning, execute and evaluation) and in academic achievement in computer.
Heggart & Yoo (2018), Australia	Pre-service teacher course (Non-STEM-related)	Quantitative design: Survey	**Remember**: Complete readings **Understand**: Answer surveys and questionnaires through Google Forms **Apply:** Contribute to discussions **Analyze**: Create mind maps through Google Draw **Evaluate**: Reflect upon own learning through GC's questioning capabilities **Create**: Sharing of materials and contribute to resources through Google Slides	Google Classroom increased student participation and learning and improved classroom dynamics. It also revealed concerns around pace and user experience. Google Classroom enables increased pace accessibility with the foster of collaboration agency and voice, which leads to quality learning.
Mafa (2018), South Africa	Healthcare Service Management (Non-STEM-related)	Quantitative design: Questionnaire	**Evaluate (Analyze)**: React to remarks, track and view their own progress in the learner's portal *Unjustifiable: Upload	Google Classroom is a powerful tool in instruction and learning among higher education learners. Learning and acquiring skills and knowledge through

(pre-service & during service) to use computer applications in various teaching and administrative work, creation of laboratories in colleges and different educational establishments to use computers in the teaching of different subjects and to train students to use it.			assignments and all the supporting documents online	Google Classroom is preferable over that which is acquired through in-classroom contacts.
Ventayen et al. (2018), Philippines	Economics, Basic Finance (Non-STEM-related)	Quantitative design: Questionnaire	**Analyze (Apply, Understand, Remember):** Answer quizzes, examination and assignment **Evaluate (Analyze):** Carry out discussion, collaborative learning and peer tutoring **Create (Evaluate, Analyze, Apply, Understand, Remember)**: Do individual project and group Project	Google Classroom is extremely useful due to its comprehensibility, attractiveness, and operability. Besides of its practicality in conducting non-academic activities, the platform is also convenient for group assignment and collaborative learning.
The use of the learning platform was generally perceived to be a positive experience, although some students did identify some concerns regarding the rapid delivery of the content, and the danger of overwhelming students through pace needs to be carefully managed.				
Alim et al. (2019), Indonesia	Teacher Training and Education (Non-STEM-related)	Qualitative design: In-depth interview	**Understand:** Obtain and read timely updates related to lessons (access multimedia equipment) **Analyze:** Carry out online discussion, give feedback by posting directly to the flow of discussions.	The use of Google Classroom was effective with various limitations: (1) not all students got an account what was provided by the lecturers because they did not have a smartphone, (2) Wi-Fi availability in the campus was limited and (3) the students did not have enough mobile data plan during the time of online discussion and some students submitted their assignments using their friends' account.
The researcher recommends facilitators to take advantage and utilize GC in their teaching in light of the fact that it gives a rehash of what they have said				

Note *justification cannot be made on the requirement of skills based on the learning activities mentioned

4. Discussion

The review of the selected past studies found that there are indeed significant achievements of Bloom's Taxonomy of Educational Objectives aligned with the learning activities carried out using GC. In addition, educators and researchers (Alim et al., 2019; Dash, 2019; Ventayen et al. 2018) also view GC as an extremely effective Learning Management System (LMS). Multiple benefits have been reported by adopting GC in conducting e-learning; such as empowering teachers to post class materials, permitting the formation of private classes and groups so that there are no interlopers to unapproved groups or classes; learners allowed to upload documents and assignments anytime to the online platform; and constant collaboration among the learners, in which they can share their thoughts online (Basher, 2017; Mafa, 2018). In addition, Basher (2017) highlighted that the learners should be encouraged to self-evaluate and develop skills in using the Internet; enhance their information and digital literacy, in order to be efficient in their respective fields.

4.1 STEM related Subjects

The selected studies which were conducted in the context of STEM-related subjects, which are Biochemistry (Dash, 2019) and data mining (Shaharanee et al., 2016) are found to involve learning activities which required more complex cognitive abilities i.e. create and evaluate. In the data mining subject, the learners were required to examine information and review what is already known using computer software tools to analyze and interpret the data. On the other hand, the biochemistry subject required the learners to perform skill and ability to create, which also involved the ability to evaluate, analyze, apply, understand, remember, in order to make certain illustrations on the topic of acid–base balance. Moreover, it has been suggested by Dash (2019) that items inquiring about better access to learning material, use of additional learning resources like YouTube videos scored high indicating effectiveness of GC. Consequently, complex STEM subjects like biochemistry stand to benefit from such innovations.

4.2 Non-STEM related Subjects

In contrary, there are five selected studies which have been conducted in the context of non-STEM-related subjects, which are teachers training and education-related subjects (Alim et al., 2019; Basher, 2017; Heggart & Yoo, 2018), healthcare service management (Mafa, 2018), and lastly economics and basic finance (Ventayen et al., 2018). It has been found that the skills of remembering, understanding, applying, analyzing, evaluating and creating are all involved in different learning activities for the non-STEM-related subjects. The learners were given the tasks to reflect on their own progress of learning, besides tracking and reacting to the feedback that they have received, in which the ability of evaluating was predominantly required in almost all of the studies. The analyzing skill was also needed for most of the learning activities that involves the answering of tests, questionnaires, quizzes and contributing to discussions. Non-STEM-related subjects, which are mostly related to the field of social science and management also stand to benefit from the practicality of GC in conducting non-academic activities. As suggested by Ventayen et al. (2018), GC encourages the peer tutoring and collaborative learning among the learners.

4.3 Implications

Meanwhile, in the context of learner's perspective, if skills, concepts and values do not interconnect in the intended outcomes, learners may not consider that particular educational technology as an integral part of their learning experience (Beetham, 2013). Therefore, educators should consider whether the online learning platform is conducive in supporting a wide range of learning objectives as they design the activities. Thence, the digital and information literacy linked to Bloom's taxonomy of educational objectives is to support the creation of practical learning outcomes while including the digital capabilities and approaches. As Zollman (2012) stated, STEM literacy in education ought to be projected in enhancing

the learning for economic, societal and personal needs, the students have to develop from "learning to *know* and *do"* to "learning to *live together* and *to* be" (p.15). By reflecting the achievement of Bloom's Taxonomy of Educational Objectives on Google Classroom learning activities, STEM literacy which promotes integration of skills and collaborative learning thus can be accessed in the era of Education 4.0. By this, the use of online learning platforms like Google Classroom can be more prevalent among the educators in the future.

5. Conclusion

To conclude, this paper critically reviewed the related literature by assessing the achievements of educational objectives aligned with the learning activities carried out using GC. The findings on the inclusion of different levels of cognitive abilities through the learning activities on Google Classroom will be able to help improve the use of online learning platforms for STEM and also non-STEM disciplines in the future. As a result, the stakeholders in the education industry will be able to grab a comprehensive picture of what is working well and what is in need of improvements to further promote e-learning, thus boosting the uptake intentions of e-learning among the educators; achieving the aspiration of Education 4.0.

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References

Alim, N., Linda, W., Gunawan, F., & Saad, M. S. M. (2019). The effectiveness of Google Classroom as an instructional media: A case of State Islamic Institute of Kendari, Indonesia. *Humanities & Social Sciences Reviews, 7*(2), 240-246. https://doi.org/10.18510/hssr.2019.7227

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman.

Azhar, K. A., & Iqbal, N. (2018). Effectiveness of Google classroom: Teachers' perceptions. *Prizren Social Science Journal, 2*(2), 52-66.

Basher, S. A. O. (2017). The impact of Google classroom application on the teaching efficiency of pre-teachers. *University of Shagra-Department of Educational Sciences, 1*(1), 45-55.

Beetham, H. (2013). Designing for active learning in technology-rich contexts. In H. Beetham, & R. Sharpe (Eds.), *Rethinking Pedagogy for a Digital Age* (pp. 55-72). Routledge.

Bloem, J., Van Doorn, M., Duivestein, S., Excoffier, D., Maas, R., & Van Ommeren, E. (2014). The fourth industrial revolution: Things to tighten the link between IT and OT. Sogeti VINT. https://www.sogeti.com/globalassets/global/special/sogeti-things3en.pdf

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook 1: Cognitive domain.* New York: David McKay.

Cropanzano, R. (2009). Writing non empirical articles for *Journal of Management: General thoughts and suggestions. Journal of Management, 35*, 1304-1311. https://doi.org/10.1177/0149206309344118

Dash, S. (2019). Google Classroom as a learning management system to teach biochemistry in a medical school. *Biochemistry and Molecular Biology Education, 47*(4), 404-407. https://doi.org/10.1002/bmb.21246

Dunwill, E. (2016, March 16). Four changes that will shape the classroom of the future: Making education fully technological. E-learning Industry. https://elearningindustry.com/4-changes-will-shape-classroom-of-the-future-making-education-fully-technological

Fisher, M. (2009, February 27). Digital bloom's visual. http://digigogy.blogspot.com/2009/02/digital-blooms-visual.html

Gerber, H. R., Abrams, S. S., Curwood, J. S., & Magnifico, A. M. (2016). *Conducting qualitative research of learning in online spaces.* SAGE Publications.

Graham, B.M. (2017, January 15). Education and the fourth industrial revolution: Learning to thrive in a transforming world. Medium. https://medium.com/regenerative-global/education-and-the-fourth-industrial-revolution-cd6bcd7256a3

Heggart, K. R., & Yoo, J. (2018). Getting the most from Google Classroom: A pedagogical framework for tertiary educators. *Australian Journal of Teacher Education*, *43*(3), 140-153.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into Practice, 41*(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2

Kumar, J. A., & Bervell, B. (2019). Google Classroom for mobile learning in higher education: Modelling the initial perceptions of students. *Education and Information Technologies, 24*(2), 1793-1817.

Liu, H. C., & Chuang, H. H. (2016). Integrating Google Classroom to teach writing in Taiwan. *Minnesota eLearning Summit.* https://pubs.lib.umn.edu/index.php/mes/article/view/730

Mafa, K. R. (2018). Capabilities of Google Classroom as a teaching and learning tool in higher education. *International Journal of Science Technology & Engineering, 5*(5), 30-34.

Martínez-Monés, A., Reffay, C., Torío, J. H., & Cristóbal, J. A. M. (2017). *Learning analytics with Google Classroom: Exploring the possibilities.* [Proceedings of the 5th International Conference on Technological Ecosystems for Enhancing Multiculturality]. United States of America. https://doi.org/10.1145/3144826.3145397

Salmon, G. (2019). May the Fourth Be with you: Creating Education 4.0. *Journal of Learning for Development-JL4D, 6*(2), 95-115.

Shaharanee, I. N. M., Jamil, J., & Rodzi, S. S. M. (2016). The application of Google Classroom as a tool for teaching and learning. *Journal of Telecommunication, Electronic and Computer Engineering, 8*(10), 5-8.

Ventayen, R. J. M., Estira, K. L. A., De Guzman, M. J., Cabaluna, C. M., & Espinosa, N. N. (2018). Usability evaluation of Google Classroom: Basis for the adaptation of G Suite e-learning platform. *Asia Pacific Journal of Education, Arts and Sciences*, *5*(1), 47-51.

Zollman, A. (2012). Learning for STEM literacy: STEM literacy for learning. *School Science and Mathematics, 112*(1), 12–19. https://doi.org/10.1111/j.1949-8594.2012.00101.x