JPII 8 (4) (2019) 447-455

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

THE DEVELOPMENT OF SCIENTIFIC IMAGINEERING LEARNING ACTIVITY THROUGH FACEBOOK TO ENHANCE LEARNERS' KEY COMPETENCIES

S. Techakosit*[1] and S. Srisakuna[2]

[1,2]Kasetsart University Laboratory School Center for Educational Research and Development, Faculty of Education, Kasetsart University, Thailand

DOI: 10.15294/jpii.v8i4.20823

Accepted: August 5th, 2019. Approved: December 27th, 2019. Published: December 31st, 2019

ABSTRACT

The development of Learners' Key Competencies (LKCs) is one of the goals of the basic education core curriculum that is currently being used in Thailand. Therefore, learning activities that enhance LKCs are essential for all teachers. The objectives of this research were to develop a Scientific Imagineering (SIG) learning activity through Facebook in enhancing LKC development and to study its effectiveness. A research and development method was used in this study. A total of 30 students of grade 11 which selected using purposive sampling participated in the learning activity. A self-assessment of LKCs form was used to investigate the situation in a physics class, before and after participation in the learning activity. The research results showed that SIG learning activity through Facebook consisted of six steps in the form of Imagine, Study, Design, Develop, Present, and Evaluate. The evaluation results by five experts concerning the suitability of this learning activity indicated that it could be used to enhance LKCs and had great potential to be implemented. Comparing the students' self-assessment with regard to LKCs, it was clear that there was a significant overall increase ($p<.05$). The comparison of students' self-assessment to the LKCs for each component also found that the skills of communication, thinking and learning, problem-solving, and technological application increased significantly ($p<.05$). The results of this study support the view that SIG learning activity through Facebook could enhance the LKCs of students.

Keywords: facebook, learners' key competencies, scientific imagineering learning activity

INTRODUCTION

Globalization and modernity are shaping a more varied and connected world, allowing individuals to understand and work efficiently in the context of a world in which the society is facing many challenges. For example, the need to develop a balance between economic and environmental sustainability and social equality means that various competencies are required by individuals, including the ability to react to the need for changing of technological expertise and the ability to understand vast amounts of data (OECD, 2005). The goal of a modern educational system is to equip students with the ability to adapt the different situations in life, to ensure that they have the ability to acquire knowledge independently, be able to apply that knowledge in solving various kinds of problems using modern technologies, think critically and creatively, use data effectively, work well in a team, and develop their moral values, intellectual, as well as cultural awareness (Dedovets &

***Correspondence Address**
E-mail: techakosit@gmail.com

Rodionov, 2015). In other words, competencies are now crucial for students in today's society.

Learners' Key Competencies

Competency is an ability to apply resources and achieve adequate learning outcomes (knowledge, skills, values, and attitudes) in specific contexts (Kabita & Ji, 2017), and the acquisition of critical competencies determines the learner's success in the future (Dedovets & Rodionov, 2015). Competencies refer not only to knowledge and skills but also the ability to respond to complex needs (OECD, 2005). Competencies include the knowledge, skills, and characteristics that allow children and young people to adequately achieve their full potential when learning the principles of any subject (Ontario Ministry of Education, 2015).

The Basic Education Core Curriculum B.E. 2551 (A.D. 2008) of Thailand constitutes the framework and sets out the direction when it comes to providing basic education in the country. Its goal is to develop learners in such a way that they can achieve specified learning standards, which will allow them to develop 5 Learners' Key Competencies (LKCs), these are: (1) Communication skill or the ability to use language to express one's ideas and to demonstrate understanding, feelings and opinions in order to efficiently and effectively exchange information; (2) Thinking skill or the ability to think critically and creatively in order to make appropriate decisions; (3) Problem-solving skill or the ability to solve problems appropriately, rationally and ethically, based on the available information; (4) Capacity for Applying Life Skills or the ability to apply processes to one's daily life, and the ability to adapt well to social and environmental change; and (5) Capacity for Technology Application or the ability to choose and use technology and technological processes to learn, communicate, work and solve problems creatively and appropriately (Office of the Basic Education, 2008). Consequently, teachers of all subjects must create instructional activities that promote and evaluate the LKCs of students throughout their school life. In order to do so, teachers must introduce various learning activities that are defined as any activities on the part of teachers organized with the intent to develop knowledge, skills, and competencies (European Union, 2016).In this research, the researchers want to present an example of a learning activity that enhances LKCs.

Facebook as an Educational Tool

At present, it is expected that all students will have developed technology fluency, digital citizenship, and other 21st Century competencies (Greenhow & Robelia, 2009). Social media is a tool that helps people share and exchange information, ideas, pictures, videos, etc. via dedicated networks (Siddiqui & Singh, 2016). One of the essential benefits of social media is the ability of different groups of people to share knowledge and information online. This develops communication skills on the part of students, which can then be applied in an educational context. Online tools and technologies are not only a means of communication in terms of variety. There are various ways to communicate, but how we talk and think about communication is changing. Online social media has the potential to change our social way of life, both at the individual and the community level (Baruah, 2012).

Facebook (FB) is a social medium that uses Web 2.0 technology. It can be accessed free of charge from any computer or mobile device with internet access. Its most prominent feature is its software interface design (Stanciu et al., 2012). FB can be used as an educational tool to facilitate resource sharing, make announcements easily and quickly, and allow interaction between an individual and other users (Jeljeli et al., 2018). Teachers can use FB to communicate with students, offer a less formal form of learning in addition to formal classroom learning, specifically allowing discussion outside the classroom (Prescott et al., 2013). FB group features allow students to have extra time to learn and give them opportunities to use learning resources outside the classroom (Davidovitch & Belichenko, 2018). The use of FB in the teaching process can improve students' social competence, the effectiveness of their thinking, teamwork, and information technology skills (Alarabiat & Al-Mohammad, 2015; Saifudin et al., 2016; Gersamia & Toradze, 2017).

Scientific Imagineering

The learning model of Scientific Imagineering (SIG) is synthesized from the scientific method and imagineering processes consisting of six steps, namely Imagine, Study, Design, Develop, Present, and Evaluate (Techakosit & Nilsook, 2016), as shown in Figure 1.

Figure 1. The Learning Model of Scientific Imagineering (Techakosit & Nilsook, 2016)

Techakosit & Nilsook (2016) proposed that using the SIG learning model in conjunction with augmented reality (AR) could develop students' STEM literacy, the ability to use concepts from Science, Technology, Engineering and Mathematics to solve problems which cannot be solved using concepts or knowledge from anyone science (Jackson & Mohr-Schroeder, 2018). The STEM literacy consists of six elements (Techakosit & Nilsook, 2018), as shown in Figure 2.

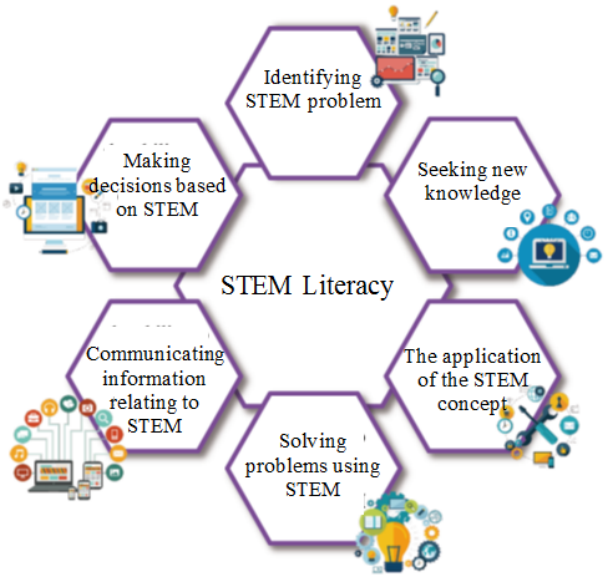

Figure 2. Elements of STEM Literacy (Techakosit & Nilsook, 2018)

As mentioned above, if considering the enhancement of each element of LKCs, SIG learning activity can improve communication and problem-solving skill as well as capacity for applying life skills. On the other hand, the use of FB as a learning tool could improve communication, thinking, and IT skill. In short, the objectives of this research were (1) to develop a SIG learning activity through FB in order to develop the LKCs in terms of a topic dealing with the spectra of electromagnetic waves and (2) to determine the effectiveness of this learning activity in terms of enhancing the LKCs on 30 students of grade 11, Kasetsart University Laboratory School Center for Educational Research and Development, Bangkok Thailand.

METHODS

The research method used was a research and development approach that has three stages consisting of planning, development, and evaluation (Richey & Klein, 2014). Besides, this research also adopted a one-group pretest-posttest design, one of the designs frequently used in the social sciences (Kemper, 2017). The participants were selected using purposive sampling because the researchers thought that, in this way, they would

optimize the information received (Moser & Korstjens, 2018). The participants consisted of 30 students of grade 11 who were learning about the spectra of electromagnetic waves (EM waves) in a physics class.

The learning activity was designed by considering the four components, including the learners, the learning environment, the learning outcomes, and the other individuals involved (Mota et al., 2014). The learning process for this research was based on the six steps of the SIG learning model employing FB as a learning tool. A 5-point Likert scale was used for evaluating the suitability of each of the learning activities. This evaluation was undertaken by five instructional design experts who hold doctoral degrees and work as lecturers at universities. The mean ratings were interpreted and described based on the level of suitability on the given indicators as follows: 4.50 - 5.00 = Extremely Suitable; 3.50 - 4.49 = Suitable; 2.50 – 3.49 = Moderate; 1.50 – 2.49 = Unsuitable; 1.00 – 1.49 = Extremely Unsuitable (Ismail et al., 2015).

Before engaging in the learning activity, the participants' LKCs were assessed using a self-assessment form. This used a *5-point Likert scale format* to measure agreement (Brown, 2010), with each LKC having seven-issue questions. These were created and presented to three measurement and evaluation experts to assess their content validity. The result of the self-assessment was analyzed using the Shapiro-Wilk test and found that the overall and LKC-specific results followed a normal distribution ($p>.05$) (Hanusz et al., 2016). The learning activity was undertaken by the participants both inside and outside the classroom in February 2019. During some parts of the outdoor classroom learning, other topics were taught. The average LKC scores using the self-assessment forms were completed before and after participating in the learning activity. The scores were compared using a dependent t-test concerning two related means of the participants (Gerald, 2018). In most studies, the overall and LKC-specific results followed a normal distribution ($p>.05$) (Prajapati et al., 2010).

RESULTS AND DISCUSSION

The design of the learning activity consists of six steps, as shown in Figure 3.

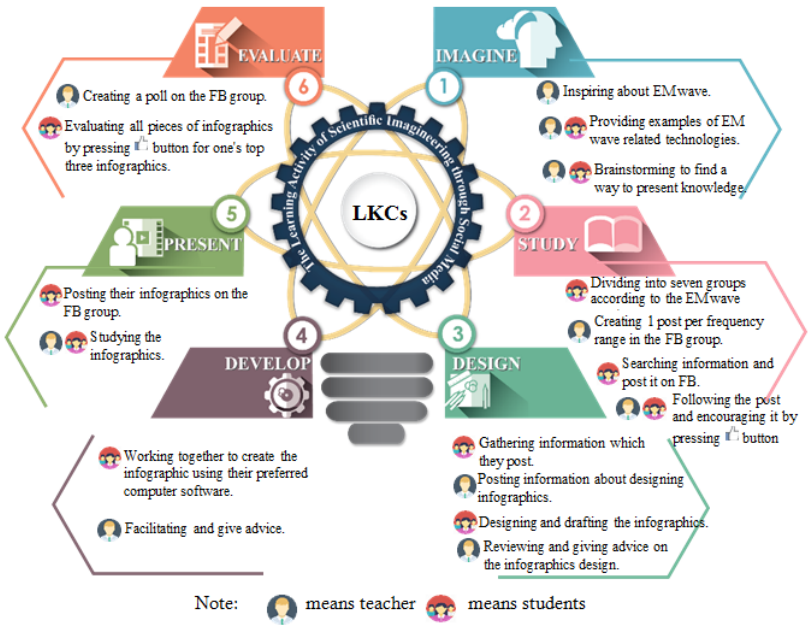

Figure 3. The SIG Learning Activity through FB on EM Wave Topic for LKCs Development

"Imagine" is the first step, during which the teacher inspires the students to learn. The teacher and the students worked together to provide examples of EM wave-related technologies so that the students came to realize the importance of EM waves. Then the students and the teacher brainstormed to find ways to present the knowledge about the spectra of EM waves. In this class, the learners chose to use infographics.

"Study" is the second step when students carry out research using various sources of knowledge. They were put into seven groups accor-

ding to the frequency range of the EM wave that the students were interested in. They then made FB posts about the knowledge they had obtained in the FB group. The learners in other groups and the teacher read the content posted, and 'liked' the posts if they found them fascinating. This act could be said to be an outdoor learning activity.

The "Design" step involves designing infographics. The students gathered information about the frequency range of the EM waves they researched, and the teacher posted information about designing infographics for all of the FB groups so that they could use it when creating their infographics. The teacher-reviewed and advised the students about how to go about this.

The "Develop" step is when the students created the infographic. The drafts they designed as part of the design step were used to create infographics using their preferred computer software, and the teacher gave them advice.

The "Present" step is when the students presented their infographics by posting comments in a thread in the FB group created by the teacher. The teacher and students studied infographics about EM waves in different frequency ranges.

The "Evaluate" step is when the students evaluated the infographics. The teacher created a poll in the FB group specifying all the frequency ranges of EM waves. Each student evaluated all infographic submissions by hitting the 'like' button to vote for their chosen top three infographics.

The result of the evaluation by five experts of the suitability of the steps of the SIG learning activity through FB is shown in Table 1.

Table 1. The Results of the Evaluation of the Suitability of the SIG Learning Activity through FB

Steps of the SIG Learning Activity through FB	Experts' Evaluation					Level of Suitability		Interpretation
	JN	SS	NT	PP	WC	$\bar{x}$	SD	
Imagine	5	4	5	5	5	4.80	0.45	Extremely Suitable
Study	5	4	5	5	5	4.80	0.45	Extremely Suitable
Design	5	4	5	5	5	4.80	0.45	Extremely Suitable
Develop	5	4	5	5	5	4.80	0.45	Extremely Suitable
Present	5	4	5	5	5	4.80	0.45	Extremely Suitable
Evaluate	5	4	5	5	5	4.80	0.45	Extremely Suitable
Overall						4.80	0.41	Extremely Suitable

The results of the evaluation by five experts on the suitability of the SIG learning activity through FB indicated that the steps were extremely suitable.

Furthermore, the results of the evaluation by five experts of the suitability of using the SIG learning activity through FB is shown in Table 2.

Table 2. The Results of SIG Learning Activity through FB Implementation

Element of Evaluation	Experts' Evaluation					Level of Suitability		Interpretation
	JN	SS	NT	PP	WC	$\bar{x}$	SD	
The enhancement of LKCs through FB-based SIG learning activity	5	4	5	5	5	4.80	0.45	Extremely Suitable
The potential of FB-based SIG learning activity to be broadly implemented	5	5	5	5	5	5.00	0.00	Extremely Suitable

The evaluation of the implementation of FB-based SIG learning activity to enhance the students' LKCs, and its potential to be broadly implemented scored 'extremely suitable'. Figure 4 shows some of the infographics created by the students.

Figure 4. The Examples of Student Infographics

The development of LKCs using the SIG learning activity through FB on the spectra of EM waves topic in a physics class is shown in Table 3.

Table 3. The Results of LKC Self-Assessment Form on Competencies Affected by the FB-based SIG Learning Activity

Learners' Key Competencies	Before		After		T-test	
	$\bar{x}$	SD	$\bar{x}$	SD	t	Sig
Communication	24.30	4.49	26.00	4.21	-2.337	.027
Thinking	23.77	5.27	26.93	3.99	-3.669	.001
Problem-solving	23.93	5.23	25.73	4.65	-2.195	.036
Capacity for applying life skills	27.07	3.69	28.30	3.85	-1.807	.081
Information Technology	26.33	4.79	29.00	4.58	-3.881	.001
Overall	125.40	18.70	135.97	17.81	-3.869	.001

A paired-samples t-test was used to compare the results of the overall and LKC-specific self-assessment scores, before and after participating in the learning activity. The overall score increased significantly ($p < .05$). As far as each LKC was concerned, it was found that communication, thinking, problem-solving, and IT skill improved significantly ($p < .05$), while the score for the capacity to apply life skills also increased yet not statistically significant.

The LKC self-assessment scores increased after the students had participated in the learning activity. The increase was in alignment with the expert evaluation, which indicated that the learning activity could enhance students' LKCs. The activity used in this study focused on allowing students to learn through the project assignment. The students were given a chance to work in groups to retrieve and summarize information in order to jointly design and create an infographic. Each group presented the infographic they created to the class, and evaluated the infographics of the other groups. While participating in this activity, the students spent time discussing the subject being studied with peers in the same group, thus enhancing the communication between group members. In the classroom, it was observed that they, in their groups, brainstormed ideas to create their infographic. During this process, they faced obstacles and problems which demanded them to think about the solution to solve these problems. This finding is in line with the results of earlier studies indicating that learning through project assignments increases general learning motivation, growth in educational interest, of students' horizons and potential, as well as develops key competencies (Dedovets & Rodionov, 2015). This is consistent with the study of Albareda-Tiana et al. (2018), who found that project-oriented learning is a learning model that is suitable for teaching and learning in a student-centered educational context. They also confirmed that this learning process helps students develop their competencies. Similarly, Anazifa & Djukri (2017), revealed that learning through the process of students engaging in projects that are similar

to a SIG learning activity affects students' creativity and critical thinking.

Using FB in this study as a tool to manage to learn, allowed the learners to study how to use social media in a way that benefits learning. Many students tend to think of FB or other social media platforms as technologies used for communicating with friends, but after participating in this learning activity, they learned how to apply FB and social media platforms to benefit their learning. The ability of the teacher is an essential tool in terms of successfully integrating technology into the classroom, helping to develop the necessary competencies of students (UNESCO, 2016). Moreover, the content dealing with EM wave spectra posted on FB by the students showed that they researched and retrieved information from reliable sources after the teacher had taught them about source reliability. FB allowed the teacher to arrange SIG learning activities in such a way as to encourage the students to communicate and share knowledge, both in and out of the classroom. This is in alignment with the research finding that FB supports learning, and students benefit from it. For example, the increase in sharing and collaboration, and motivate communication and discussion among students and between students and the teacher (Cunha et al., 2016). FB is an efficient instructional tool that significantly enhances students' learning, as well as their achievements in terms of academic activities (Mbodila et al., 2014). Furthermore, the application of FB to the learning activity in a way that suits social needs and the context of the classroom leads to an increase in digital technology usage in school (Cunha et al., 2016). It enhances the students' opportunities to develop the capacity for technological applications.

Another key reason for the increase in the students' LKC self-assessment scores after participating in this learning activity was that the EM wave spectra infographic assignment required them to use several different abilities to create compelling infographics. Therefore, the students felt that, as a result of participating in the learning activity designed especially for this research, their LKCs were enhanced. This is in line with a previous study which found that assigning students to create infographics allows them to develop key digital literacy skills such as scrutinizing information. Therefore, assigning an infographic task was introduced as an experiential learning tool that allowed students to apply key competencies in the form of content management and content creation (Matrix & Hodson, 2014).

The infographic assignment developed 21st Century capacities such as critical and creative thinking (Dyjur & Li, 2015), which is one of the five components of LKCs' thinking capacity. In terms of the self-assessment for the capacity to apply life skills before and after participation in the learning activity, there was no significant change, despite an earlier study, which suggested that making an infographic could potentially enhance life skills (Alrwele, 2017). This may happen since there were too many students in each group, and too much time was allowed for the assigned task. The content about the EM wave spectra assigned to each group was also too little. Therefore, the students did not appreciate the value of the process nor feel proud of their contribution to the successful completion of the project.

CONCLUSION

The results of this study revealed that the FB-based SIG learning activity consists of six steps, Imagine, Study, Design, Develop, Present and Evaluate, while the learning activity happened both inside and outside the classroom. The expert evaluation showed that the designed learning activity is highly suitable in terms of developing the students' LKCs. After having the students participate in this learning activity, their self-assessment scores concerning LKCs increased significantly following their participation. Their self-assessment scores about communication, thinking, problem-solving, and IT skills increased significantly, while no significant change was noted in the score of the capacity for applying life skills.

In general, the results of this study provide essential evidence that SIG learning activity through Fbcould enhance LKCSs by providing the students with the opportunity to collaborate in a search for knowledge and the creation of artifacts. The results of this study also support the view that the development of LKCs can occur in the general classroom if the teacher selects appropriate learning activities in conjunction with the selection of technology that promotes student learning. This learning activity is an example of what teachers can apply in the classroom in various subjects to develop the competencies needed by the students in the current societal life.

REFERENCES

Alarabiat, A., & Al-Mohammad, S. (2015). The Potentialfor Facebook Application in Undergraduate

Learning: A Study of Jordanian Students. *Interdisciplinary Journal of information, Knowledge, and Management, 10*, 81-103.

Albareda-Tiana, S., Vidal-Raméntol, S., Pujol-Valls, M., & Fernández-Morilla, M. (2018). Holistic Approaches to Develop Sustainability andResearch Competencies in Pre-Service Teacher Training, *Sustainability, 10(10), 1-20.*

Alrwele, N. S. (2017). Effects of Infographics on Student Achievement and Students' Perceptions of the Impacts of Infographics. *Journal of Education and Human Development, 6*(3), 104–117.

Anazifa, R.D., & Djukri. (2017). Project-based Learning and Problem-based Learning: Are They Effective to Improve Student's Thinking Skills?. *Jurnal Pendidikan IPA Indonesia, 6*(2), 346-355.

Baruah, T. D. (2012). Effectiveness of Social Media as a Tool of Communication and Its Potential For Technology Enabled Connections: A micro-Level Study. *International Journal of Scientific and Research Publications, 2*(5), 1–10.

Brown, S. (2010). *Likert Scale Examples for Surveys*. Retrieved from https://www.extension.iastate.edu/Documents/ANR/LikertScaleExamplesforSurveys.pdf.

Cunha, Jr. F. R., van Kruistum, C., & van oers, B. (2016). Teachers and Facebook: Using Online Groups to Improve Students' Communication and Engagement in Education. *Communication Teacher, 30*(4), 228–241.

Davidovitch, N., & Belichenko, M. (2018). Facebook Tools and Digital Learning Achievements in Higher Education. *Journal of Education and e-learning Research, 5*(1), 8–14.

Dedovets, Z., & Rodionov, M. (2015). The Development of Student Core Competencies through the STEM Education Opportunities in Classroom. *International Journal of Social, Behavioral, Educational, Economic and Management Engineering*, *9*(10), 2748-2751.

Dyjur, P., & Li, L. (2015). Learning 21st Century Skills by Engaging in an Infographics Assessment. In Preciado Babb, P., Takeuchi, M., & Lock, J. (Eds.). Proceedings of the IDEAS: Designing Responsive Pedagogy Conference, (pp. 62-71). Calgary, Canada: Werklund School of Education, University of Calgary.

European Union. (2016). *Classification of Learning Activities (CLA) Manual 2016 edition*. Retrieved from https://ec.europa.eu/eurostat/documents/385 9598/7659750/KS-GQ-15-011-EN-N.pdf/978de2eb-5fc9-4447-84d6-d0b5f-7bee723

Gerald, B. (2018). A Brief Review of Independent, Dependent and One Sample T-Test. *International Journal of Applied Mathematics and Theoretical Physics, 4*(2), 50-54.

Gersamia, M., & Toradze, M. (2017). Communication Function of Social Networks in Media Education: The Case of Georgia. *Athens Journal of Mass Media and Communication, 3*(3), 195-206.

Greenhow, C., & Robelia, B. (2009). Informal Learning and Identity Formation in Online Social Networks. *Learning, Media and Technology, 34*(2), 119–140.

Hanusz, Z., Tarasinska, J., & Zielinski, W. (2016). Shapiro-Wilk Test with Known Mean. *REVSTAT – Statistical Journal, 14*(1), 89-100.

Ismail, F., Jabar, I. L., Janipha, N.A. I., & Razali, R. (2015). Measuring the Quality of Life in Low Cost Residential Environment. *Procedia-Social and Behavioral Sciences, 168*(2015), 270-279.

Jackson, C. D., & Mohr-Schroeder, M. J. (2018). Increasing Stem Literacy Via an Informal Learning Environment. *Journal of STEM Teachwr Education, 53*(1), 43-52.

Jeljeli, R., Alnaji, L., & Khazam, K. (2018). A Comparison Between Moodle, Facebook, and Paper-based Assessment Tools: Students' Perception of Perference and Effect on Performance. *International Journal of Emerging Technologies in Learning, 13*(5), 86–99.

Kabita, D. N., & Ji, L. (2017). *The Why, What and How of Competency-Based Curriculum Reforms : the Kenyan Experience*. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000250431.

Kemper, H. (2017). Haptotherapy and Science. *International Journal of Haptonomy and Haptotherapy,* 1-17.

Matrix, S., & Hodson, J. (2014). Teaching with Infographics: Practicing New Digital Competencies and Visual Literacies. *Journal of Pedagogic Development, 3*(2), 17-27.

Mbodila, M., Ndebele, C., & Muhandji, K. (2014). The Effect of Social Media on Student's Engagement and Collaboration in Higher Education: A Case Study of the use of Facebook at a South African University. *Journal of Communications, 5*(2), 115–125.

Moser, A., & Korstjens, I. (2018). Series: Practical Guidance to Qualitative Research. Part 3: Sampling, Data Collection and Analysis. *European Journal of General Practice, 24*(1), 9-18.

Mota, D., Reis, L. P., & de Carvalho, C. V. (2014). Design of Learning Activities-Pedagogy, Technology and Delivery Trends. *ICST Trans. e-Education e-Learning*, *1*(4), 1 – 11.

OECD. (2005). *The Definition and Selection of Key Competencies: Executive Summary*. Retrieved from https://www.oecd.org/pisa/35070367.pdf.

Office of the Basic Education (2008) *The Basic Education Core Curriculum B.E.2551 (A.D.2008).* Bangkok: Ministry of Education.

Ontario Ministry of Education (2015). *Towards Defining 21st Century Competencies for Ontario*. Retrieved from https://ocea.on.ca/wp-content/uploads/2018/02/21cl-21stcenturycompetencies.pdf

Prajapati, B., Dunne, M., & Armstrong, R. (2010). Sample Size Estimation and Statistical Power Analyses. *Optometry Today*, *16*(07), 10-18.

Prescott, J., Stodart, M., Becket, G., & Wilson, S. (2013). The Experience of Using Facebook as an Educational Tool. *Health and Social Care Education*, 1-5.

Richey, R. C., & Klein, J. D. (2014). *Design and Development Research: Methods, Strategies, and Issues*. Routledge.

Saifudin, A. M., Yacob, A., & Saad, R. (2016). The Facebook-in-Action: Challenging, Harnessing and Enhancing Students Class Assignments and Projects. *Universal Journal of Educational Research*, *4*(6), 1259-1265.

Siddiqui, S. & Singh, T. (2016). Social Media its Impact with Positive and Negative Aspects. *International Journal of Computer Application Technology and Research, 5*(2), 71–75.

Stanciu, A., Mihai, F., & Aleca, O. (2012). Social Networking as an Alternative Environment for Education. *Accounting and Management Information Systems, 11*(1), 56–75.

Techakosit, S., & Nilsook, P. (2016). The Learning Process of Scientific Imagineering through AR in order to Enhance STEM Literacy. *International Journal of Emerging Technologies in Learning, 11*(7), 57–63.

Techakosit, S., & Nilsook, P. (2018). The Development of STEM Literacy Using the Learning Process of Scientific Imagineering through AR. *International Journal of Emerging Technologies in Learning (iJET), 13*(1), 230–238.

UNESCO. (2016). Diverse Approaches to Developing and Implementing Competency-based ICT Training for Teachers: A Case Study. Retrieved from https://bangkok.unesco.org/content/diverse-approaches-developing-and-implementing-competency-based-ict-training-teachers-case