Development and Evaluation of Instructional Materials in Physics for Non-STEM Engineering Students

Dr Alan N. Muñoz
[1] Iloilo Science and Technology University, Burgos St., La Paz, 5000 Iloilo City
Email: alan.munoz@isatu.edu.ph

Abstract
This study aimed to develop an enhanced physics instructional material for Non-STEM Engineering students. The ePhysics Module adopted Merrill's Principle of Instructional Design. It was implemented for 30 non-STEM second-year engineering students via Google Meet. Results showed that the quality of the enhanced instructional material in physics in terms of learning outcomes, contents, activities, assessment, design and presentation was excellent. The student's experiences using the enhanced instructional material in physics were the following: instructional material in physics was relevant and easy to understand, enjoyable and exciting, and reflective. The teacher implementer finds the material relevant and engaging and contains real–world application of engineering lessons, making learning meaningful. The Physics instructors should take the initiative in utilising ePhysics Module as the learning modality for this "new normal" way of teaching.
Keywords: Development, evaluation, instructional material, physics

1. INTRODUCTION

The goal of 21st-century learning is to produce “scientifically, technologically, and ecologically literate”, productive members of society who can solve complex problems, protect the environment, make thoughtful decisions, and effectively communicate. Ocampo (2015) stressed that we are developing lifelong learners with critical thinking and technical skills to find and create meaningful opportunities wherever they are. She believed that developing problem solvers who can make rational choices on issues confronting them should gain essential communication skills, critical thinking, collaboration, and creation.

Among the many reasons for the student's low performance in physics is that many students need help understanding physics. There are other factors which affect the students' achievement in physics. This factor includes the student's learning styles, preconceptions, mathematical background, cognitive development level, attitudes towards physics, prior learning experiences, socio-economic status, age and gender. Other factors considered are the subject matter factor which includes the nature of physics, learning facilities and materials and the teacher factor, which includes teaching strategies, instructional materials and teacher characteristics (Cho & Back, 2019)

Casual observations of students' performance by the researcher in his 20 years of teaching physics suggested that many physics students needed to do better than one would desire. This observation is evidenced by the low performance in quizzes and significant examinations that he and other physics instructors set them and by the considerable proportion of students that have to re-enrol in the subject due to failure. More often than not, students need more mathematical concepts and principles and the skills to solve physics problems. Failure to acquire the skills will likely redound to loss in science subjects, particularly physics. Informal conversations with students revealed that many claimed physics is tedious and difficult to understand.

In particular, “when used successfully in schools that cater to the needs of the students, quality instructional materials enable teachers to better support students in better mastering the skills, knowledge, and experience that will benefit them in school and life. Additionally, the use of instructional materials (modules) helps teachers determine the degree to which a learner has accomplished a learning target or competency” (Kibe, 2011).

The use of instructional learning materials is one of the many instructional strategies used to support teaching and learning content, enable students to apply concepts, and offer a chance for an evaluation process by displaying the data required to acquire knowledge and skills (Colson, 2017).

The development and evaluation of instructional materials to assist learning of content, enable application of concepts by students, and offer a venue for evaluation are the main topics of this study. All students in a class will have the chance to share experiences necessary for new learning, which will help make learning more relevant. It will also assist clarify crucial concepts to pique and maintain students' interests. Consequently, this investigation was carried out in light of the identified issue.

2. LITERATURE REVIEW

2.1 Mathematics Competencies and Physics Performance

Mathematics is the language of physics. This result implies that mathematics is instrumental in understanding the laws of physics. Mathematical knowledge is requisite in learning physics (Hewitt, 2011). Bacay (2019), in his scientific paper, expounded that if you want to make measurable predictions to test your theories, you need a language that can accommodate much more precise and complex statements than any natural language is capable of. Mathematics plays a vital role in learning physics. “The interaction of physics and mathematics in education leads to a more effective educational policy able to correct the existing distortion and shortcomings of physics education” (Galilei, 2012).

According to Niss (2002), mathematical competence is the capacity to comprehend, evaluate, perform, and use mathematics in a variety of intra- and extra-mathematical settings and circumstances where mathematics is present or might be relevant. Understanding and utilising various types of representations of mathematical objects, phenomena, and situations; understanding and utilising the relationships between various pictures of the same entity, including knowing about their respective strengths and limitations; choosing and utilising different representations of the same entity; and posing and solving mathematical problems are all examples of mathematical reasoning (Niss, 2002).

In order for the next generation to register in the crucial STEM (Science, Technology, Engineering, and Mathematics) subjects, it is crucial that the relationship between mathematics and physics in secondary school be strengthened.

2.2 Problem-Solving Skills and Physics Performance

Problem-solving is a skill which the 21st-century learner develops. This skill must be mastered by students in curriculum 2013 (K-12). Problem-solving skill is required to achieve the objectives of higher general education in the engineering program to give students the life skills to be an individual citizen who is faithful, productive, innovative, and practical, as well as able to contribute to social life, nation, country and world civilisation (CMO No. 20.,s. 2013).

In physics teaching, “problem-solving skill” is one of the main topics in physics education research because it has long-term benefits. Furthermore, problem-solving skills can help students understand physics concepts in absolute terms (Adams & Weiman, 2008).

Four key characteristics of problem-solving are outlined by Carlson and Bloom (2005): resources, heuristics, monitoring, and affect. Resources include procedural and factual information as well as conceptual knowledge of a given content area. Heuristics are general approaches to problem resolution that might resolve a problem or make it workable. According to Selden et al. (2000), heuristics should expand in line with the breadth and variety of students' problem-solving experiences.

According to Dawkins and Epperson (2014), students who don't acquire a foundational understanding of thinking in the algebraic and graphical registers will have much less success with calculus problems. Second, algebraic techniques are still used by top students to address calculus-related problems after they graduate from secondary school. The mathematics education program states that various problem-solving strategies are to be taught to students so they can solve multiple problems (Yazlik & Erdogan, 2016). Sokpe (2014) in his paper pointed out “the importance of problem-solving in mathematics to benefit the student, better represent the subject, and benefit the teacher. The role of the teacher is to mentor and guide the students to work independently on a mathematical problem”.

Mathematical ability grows through problem-solving. It provides students with the means to use their understanding of mathematics to address both hypothetical and practical issues. The nature of mathematics is better reflected by problem-solving. This method is regularly employed in research mathematics.

2.3 Development of Instructional Materials

“Every teacher needs supplies and resources in order to have successful classroom instruction”. Instructional materials are valuable guides to supplement instruction. In designing and developing instructional materials for teaching and learning purposes, instructional design theories and models, learning theories, pedagogy, and the media employed must be considered (Branch & Kopcha, 2014).

According to Ganiron (2015), instructional design is a systematic method for creating training and education that is reliable and consistent. It can also be viewed as a framework for creating modules or lessons that increase and enhance learning opportunities, make knowledge and skill acquisition more efficient, effective, and appealing, and motivate learners' engagement to help them learn more quickly and with greater depth (Papas, 2017). In a word, instructional design is the process of developing effective and efficient learning. In order to best support learning, it is a practise to develop instructional experiences.

Additionally, “to guarantee the quality of training, instructional design is the systematic construction of instructional requirements utilising learning and instructional theory. It encompasses the complete process of analysing learning objectives and the need to build a delivery system to meet those demands. It includes developing instructional materials and activities; and try-out and evaluating all instructional and learner activities” (Gutierrez, 2018). One of the most widely used models for preparing instructional material is the ADDIE

Instructional model. It has five stages: “Analysis, Design, Development, Implementation, and Evaluation” (Forest, 2014).

The design has been used in the design of online courses, design blended courses in Chemistry (Shibley et al., 2011) and applied by librarians to develop effective information literacy instruction (Davis, 2013). It was found that using this model can result in education that focuses on learning outcomes relevant to students, meet students' needs, and facilitate active learning (Reinbold, 2013).

Learning experiences should be authentic and produce natural–world learning environments allowing learners to construct their knowledge. This view shifted from the knowledge acquisition to the knowledge-construction metaphor (UNESCO, 2014).

There are some instructional materials to choose from. However, to design instructional material in Physics for engineering students, using the POE learning Model was deemed proper. According to Hudson and Rotman (2019), this educational resource uses an inquiry-based learning approach to assist students answer science-related questions, become aware of problem-solving challenges, and develop critical thinking skills. According to Butler and Winne (1995), inquiry is a potent tool for students to develop strategic thinking and topic mastery. Inquiry is characterised as the process of self-correction and self-adjustment (Bloom & Niss, 1991). In inquiry-based learning, students combine scientific procedures with scientific knowledge as they reason and think critically about evidence and explanations to increase their grasp of science and capacity to convey scientific ideas (Cerbin, 2011).

The distinct features of the instructional material in physics utilised Merrill's Principle of Instructional Design. According to Merrill (2011), instructional design can be used when designing any program or practice to achieve effective and efficient instruction. The method uses the principle of Activation, Demonstration, Integration, and Application.

3. PURPOSE OF THE STUDY

This study was conducted to develop and evaluate the instructional material in physics to be used by Non-STEM Engineering students.

Specifically, the study sought answers to the following questions:

1. “What instructional material in physics can be prepared based on students' least-mastered competencies in mathematics, physics and learning styles?”
2. “What are the experts' assessments of the developed instructional material in physics regarding objectives, contents, activities, assessment, design, and presentation?”

4. SIGNIFICANCE OF THE STUDY

This study aimed to help students develop strategies for learning physics effectively by developing instructional material in physics. Every student has to understand that learning physics requires critical thinking or problem-solving and different way of learning it. Awareness of these skills can help them think of ways to improve their performance in physics. Since this study recognises the influence of mathematics competencies, problem-solving skills, learning styles, and developing instructional materials in physics to enhance the performance of students in physics, the researcher hopes that the findings of this study may benefit the following:

5. METHODOLOGY

5.1 Research Design

The type 1 developmental research approach was employed in this study to combine studies on the development process (Richey, 1997). The fundamentals of developmental research were upheld over the entire investigation. Analysis, design, development, implementation, and evaluation were the iterative phases that the study was broken down into (Wang & Hannafin, 2005).

5.2 Participants

The participants for developing and evaluating the instructional material in physics were done with a team of ten (10) experts, five technical experts, and five subject matter experts. The experts were determined using the following criteria: "(a) has practical knowledge and training in the use of technology in education, (b) has at least five years experience in education and engineering as a teacher, and (c) is willing to take part in the research". Additional criteria for the technical experts were: "(a) has knowledge and experience in instructional design; and (b) has experience in using the latest technology for teaching and learning". For subject-matter experts, the additional criterion was to have at least five years of experience teaching Physics and Mathematics in engineering.

In the Implementation stage, the instructional material in physics was tried out to 30 Non - STEM second-year Bachelor of Science in Electrical Engineering students by one engineering faculty as teacher implementer via Google Meet and Google Classroom.

5.3 Instruments

A validated evaluation form was used as an instrument to develop and evaluate the instructional material in physics in terms of (a) learning objectives, (b) content, (c) activities, (d) design and presentation and (e) assessment.

5.4 Data Collection Procedure

The instrument was administered to the participants via google classroom. The gathered data was collected, analysed and interpreted.

5.5 Data Analysis Procedure

The researcher used the frequency count, percentage, ranking, mean and standard deviation to analyse the data collected in the study.

6. RESULTS AND DISCUSSION

The main goal of the evaluation was for the experts to rate the overall quality of the developed instructional material in physics in terms of Learning Outcomes, contents, activities, assessment of learning outcomes, design, and presentation. Ten (10) experts scanned and evaluated the instructional material in physics.

Table 1 shows the experts' assessment of the instructional material in physics in terms of learning outcomes. The learning outcomes of the instructional material in physics are "*excellent*", with an overall rating of $(M=3.54, SD=0.464)$.

The finding connotes that the learning activities/competencies included in the module are sufficient to attain the learning outcomes. Moreover, stating the objectives in specific, measurable, attainable, relevant, and time-bound (SMART) helps provides the clarity, focus and motivation you need to achieve your goals.

Table 1. *Experts Assessment of ePhysics Module in Terms of its Learning Outcomes (n=10)*

	S.D.	*M*	Description
"A list of specific objectives accompanies the module".	0.527	3.50	Excellent
"The objectives suit the particular topic".	0.316	3.90	Excellent
"The objectives are clear and simple".	0.421	3.20	Excellent
"The objectives are fitted to the level and needs of the learners".	0.527	3.50	Excellent
"The objectives are attainable".	0.527	3.50	Excellent
Overall Rating	0.464	3.52	Excellent

As indicated in Table 2, the findings revealed that the contents of the instructional material in physics jive with the lesson's learning outcomes. Moreover, the contents include the learning activities such as practice exercises with information about the presented study. It can be deduced from the result that respondents found that the range of the developed instructional material in physics is extensive and covers all tasks encompassing the syllabus to develop needed and required competencies.

Table 2. *Experts Assessment of ePhysics Module in Terms of its Learning Content*” ***(n=10*)**

	S.D.	*M*	Description
"Content is easily understood"	0.527	3.50	Excellent
"Content is adequate to attain the objectives"	0.516	3.40	Very Good
"The content is clear and well-organised"	0.527	3.50	Very Good
"Content is up to date"	0.516	3.60	Very Good
"Content is reliable"	0.516	3.50	Very Good
Overall Rating	0.520	3.50	Very Good

Note: "Description is based on the following scale. 3.51-4.00 (Excellent), 2.51- 3.50 (Very Good), 1.51-2.50 (Fair), 1.00-1.50 (Poor)"

The data in Table 3 reveal that the learning activities of the developed instructional material in physics were Excellent (*M* =3.66, *SD* = 0.486).

"Given this, the experts stressed that the learning activities in the instructional material in physics are contextualised having a rating of excellent which garnered the highest mean of M=3.80 and SD of 0.421. Similar ratings of excellent were given to activities are congruent to the objectives of the lesson (*M*=3.70, *SD*= 0.483). The enrichment activities can help students improve their understanding of the lesson (*M*=3.70, *SD*= 0.483). The activities are engaging and self-motivating and, within the context of the learners, were rated "very good" (*M*=3.50, *SD*= 0.527)".

Table 3. *Experts Assessment of ePhysics Module in Terms of its* ***Learning Activities (n=10)***

	S.D.	*M*	Description
"Activities are congruent with the objectives of the lesson"	0.483	3.70	Excellent
"Activities are contextualized"	0.481	3.80	Excellent
"Activities are engaging, self-motivating, and within the context of the learners"	0.527	3.50	Very Good
"The activities enhanced the knowledge and skills of the students"	0.516	3.60	Excellent
"Enrichment activities can help students improve their understanding of the lesson"	0.483	3.70	Excellent
Overall Rating	0.486	3.66	Excellent

Note: "Description is based on the following scale. 3.51-4.00 (Excellent),2.51-3.50 (Very Good), 1.51-2.50 (Fair), 1.00-1.50 (Poor)"

The figure in Table 4 shows that the assessment of learning outcomes of the instructional material in physics was "excellent" (*M*=3.66, *SD*= 0.496). This result indicates that the ePhysics module has complete, coherent, appropriate information and accurate evidence.

Table 4. *Experts Assessment of ePhysics Module in Terms of its* ***Assessment of Learning Outcomes (n=10)***

	S.D.	*M*	Description
"The module provides formative assessment for learners."	0.483	3.70	Excellent
"Assessment enhances the knowledge, understanding and skills of the learners."	0.483	3.70	Excellent
"Assessment is congruent with the objectives of the lesson."	0.516	3.60	Excellent
"Assessment challenge students to think critically."	0.483	3.70	Excellent
"Assessments are adequate to measure students' learning."	0.516	0.516	Excellent
Overall Rating	0.496	3.66	Excellent

Note: "Description is based on the following scale. 3.51-4.00 (Excellent),2.51-3.50 (Very Good), 1.51-2.50 (Fair), 1.00-1.50 (Poor)"

The result of the study indicates that the assessment of the developed instructional material in physics is suited to the level and needs of the students, aligned to the learning outcomes, and exercises are adequate to cover the topic discussed in the module and stimulate higher-order thinking skills.

Coherent with the result of the study, it is supported by the findings of Cruz (2015) that the assessment must provide information for teachers which will serve as a basis for decision-making related to any aspects of the instructional materials and, thus, if necessary, for redesigning of the instructional materials.

Table 5 shows that the design and presentation of the developed instructional material in physics were excellent (*M*=3.54, *SD*= 0.514). The rating *indicates* that the instructional material in physics has excellently met the standard, appealing and presentable.

Table 5. *Experts Assessment of ePhysics Module in Terms of its Design* ***and Presentation (n=10)***

	SD	*M*	*Description*
"The presentation is clear by observing correct grammar."	0.527	3.50	Very Good
"The layout of the module is appealing."	0.516	3.60	Excellent
"The illustrations are clearly presented and adequately labelled."	0.516	3.40	Very Good
"Font style, font size, and spacing are appropriate for teachers regardless of age."	0.483	3.70	Excellent
"Language is clear and appropriate for teachers of all ages."	0.527	3.50	Very Good
Overall Rating	0.354	3.54	Excellent

Note: "Description is based on the following scale. 3.51-4.00 (Excellent),2.51-3.50 (Very Good), 1.51-2.50 (Fair), 1.00-1.50 (Poor)"

7. CONCLUSIONS AND RECOMMENDATIONS

The instructional material in physics was excellent in terms of the learning outcomes, content, activities, assessment of learning outcomes and design and presentation, and quality. This outcome means that the Non-STEM engineering students can use the instructional material as a supplementary text to address their deficiencies in mathematics and problem–solving skills in physics.

It is recommended that school administrators and textbook writers look into the suitability of the content to all kinds of learners considering the present situation in integrating the use of the ePhysics module as a tool to facilitate discussion of concepts and principles of physics in an online and printed mode of learning in a way such that learners will appreciate and become engaged.

References

[1] Ambayon, C.M. (2020). Modular-based approach and students' achievement in science. Published Master's Thesis. College of Teacher Education, Sultan Kudarat State University, Mindanao, Philippines. Educational researcher, 23, 5-12, retrieved from http://dx.doi.org/10.3102/0013189X023007005

[2] Bacay K.P., Bacay E. (2019). Mathematics Learning Style and Problem-Solving Performance in Mathematics of Grade 11 Students, *IOER International Multidisciplinary Research Journal 1* (2), 65 -77.

[3] Braun, V. & Clarke, V. (2006). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. The Psychologist, 26(2). 123–123. ISSN 0952-8229 Pp 77-101. ISSN 1478 – 0887, retrieved from https://eprints.uwe.ac.uk/2115.

[4] Bruner, J.S. (1977). The Act of Discovery. Harvard Educational Review, 31,21-32.

[5] Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research*, 65, 245-281, retrieved from https://www. Feedback.learning.phys.com/

[6] Cançado L., Reisel J. & Walker C. (2018). *International Journal of Mathematical Education in Science and Technology*, Volume 49, 2018 - Issue 6 Published Online: retrieved from https://www.tandfonline.com/doi/abs/10.1080/0020739X.2017.1423120

[7] Corbin, W. (2011). Understanding learning styles: A conversation with Dr. Bill Cerbin. Interview with Nancy Chick. *U.W. Colleges Virtual Teaching and Learning Center*, retrieved from https://cft.vanderbilt.edu/guides-sub-pages/learning-styles-preferences/

[8] Cherry, K (2019).The Experiential Learning Theory of David Kolb. Science Daily. Retrieved from https://www. Science daily.com/releases/2009/03/090325391834.htm.

[9] Chiu, S. K. (2019). Innovative experiential learning experience: Pedagogical adopting Kolb's learning cycle at higher education in Hongkong. *International Journal of Education, Learning and Training*, Vol. 4 (No.2). Retrieved from https://www.tandfonline.com/doi/full/10.1080/2331186X.2019.1644720

[10] Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). Learning styles and pedagogy in post-16 learning. A systematic and critical review. London: Learning and Skills Research Centre.

[11] Cruz, N. (2015). Implementing the mother tongue-based multilingual education in grade I in the public elementary schools in Pangasinan I. Asia Pacific Journal of Multidisciplinary Research 5, no. 2(2017): 43–50.

[12] Davis, A.L. (2013). Using instructional design principles to develop effective information literacy instruction. College & Research Libraries News.

[13] Dahl B. (2017). First-Year Non-STEM Majors' Use of Definitions to Solve Calculus Tasks: Benefits of Using Concept Image over Concept Definition, *International Journal of Science and Mathematics Education* 15:7, pages 1303–1322, retrieved from https://link.springer.com/article/10.1007/s10763-016-9751-9

[14] Dawkins, P. C., Epperson, J. (2014). The development and nature of problem-solving among first-semester calculus students. *International Journal of Mathematical Education in Science and Technology* 45:6, pages 839-862, retrieved from https://www.tandfonline.com/doi/abs/10.1080/0020739X.2014.884645

[15] Hudson, H.T. & Rottmann, R.M. (2019). Correlation between performances in physics and prior mathematics knowledge. Journal of Research in Science Teaching. 18(4), 291-294. Retrieved from https://doi.org/10.1002/tea.3660180403

[16] Landsberger, J. (2012). Study guides and strategies: Visual/Spatial Learning. Scientific Research Journal, 34(2), 13-18. Retrieved from

https://www.studygs.net/visual.htm.

[17] Larkin, J. & Rief, F (1979). Analysis and teaching of a general skill for studying scientific text. *Journal of Educational Psychology, 68*(4), 431–440, retrieved from https://doi.org/10.1037/0022-0663.68.4.431

[18] Mayer, J.D. (1990). Cognitive and Goal Processing. Published Article. *Journal of Educational Psychology, 78*(4), 431–440, retrieved from https://doi.org/10.2190/DUGG-P24E-52WK-6CDG.

[19] Merill, M.D. (1983). Component Display Theory. Instructional Design Theories and Models: An overview of their Current States, Reigeluth, C.M (ed). Hillsdale. NJ: Lawrence Eribaum.

[20] Nelson, T.O. & Dunlosky, J. (1991). The delayed-JOL effect: When delaying your judgments of learning can improve the accuracy of your metacognitive monitoring. *Psychological Science*, 2, 267-270.

[21] Nilsen T., Angell C., Grønmo L. S. (2013). Mathematical competencies and the role of mathematics in physics education: A trend analysis of TIMSS Advanced 1995 and 2008, *Acta Didactica Norge.*

[22] Niss M. (2002). Mathematical competencies and the learning of mathematics: the Danish kom project, retrieved from http://www.math.chalmers.se/Math/Grundutb/CTH/mve375/1112/docs/KOMkompetenser.pdf

[23] Reid J., Wilkes J. (2016). Developing and applying quantitative skills maps for STEM curricula, with a focus on different modes of learning. *International Journal of Mathematical Education in Science and Technology* 47:6, pages 837–852, retrieved from https://www.tandfonline.com/doi/abs/10.1080/0020739X.2016.1144814.

[24] Reinbold, S. (2013). Using ADDIE model in designing library instruction. Med Ref ServeQ 32(3), 244–56. Retrieved Doi:10.108/02763869.2013.806859.

[25] Richey, R. (2005). Developmental Research Method: Creating Knowledge from Instructional Design and Development Practice. Journal of Computing in Higher Education. 16(2), 23–38.

[26] Rylands L.J. & Coady C. (2009). Performance of students with weak mathematics in first-year mathematics and science, *International Journal of Mathematical Education in Science and Technology*, Volume 40, 2009 - Issue 6 Published Online: 04 Aug 2009. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/00207390902914130

[27] Selden J, Selden A, Mason A. Even good calculus students can't solve non-routine problems. Research Issues in Undergraduate Mathematics Learning. MAA Notes. 33: Mathematics Association of America; 1994. p. 19-26.

[28] Simpson, J. & Fernandez, E. (2012). Student Performance in First Year, Mathematics and Physics Courses: Implications for Success in the Study of Electrical and Computer Engineering. Journal of Engineering Education. 54(7), 345-348. Retrieved from https:// https://core.ac.uk/download/pdf/46962127.pdf

[29] Schunk, D.H. (2004). Learning theories: an educational perspective. 2nd edition. New Jersey. Prentice Hall, Inc.

[30] Shibley, I., Shank, J., & Shibley, L. (2011). Designing a blended course: Using ADDIE to guide instructional design. Journal of College Teaching, 40 (6), 80–85.

[31] Sokpe, D. (2014). Discuss Why Problem-Solving Has Been Identified as A Desirable feature In Mathematics Education. *Research in Problem-Solving in Mathematics Education*, University of Cape Coast, Department of Science and Mathematics Education.

[32] Tan, R. & Dejoras, A.W. (2019). Comparing problem-solving ability of STEM and

[33] Non-STEM entrants to engineering mathematics. Published Research. Science Journal of Engineering Education. 78(8), 89-93.

[34] Tobias, S., & Everson, H. (2002). Knowing what you know and what you don't: Further research on metacognitive knowledge monitoring. *College Board Report No. 2002-*

[35] UNESCO. (2014). UNESCO Education Strategy 2014 – 2021. United Nations Educational, Scientific and Cultural Organization, p. 7 place de Fontenoy, 75352 Paris 07 SP, France.

[36] Voigt M., Apkarian N., Rasmussen C., the Progress through Calculus Team. (2019). Undergraduate course variations in precalculus through Calculus 2. *International Journal of Mathematical Education in Science and Technology* 0:0, pages 1–18. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/0020739X.2019.1636148

[37] Wang, F. & Hannafin, M.J. (2005). Design-based research and technology learning environments. Technology Research and Development, 53(4), 5-23. Retrieved from https://reasearchgate.net/publication/02504682.

[38] Westera, W. (2001). Competences in education: a confusion of tongues. *Journal of Curriculum Studies, 33* (1), 75–88.