Innovation And Chemical Entrepreneurship: Chemistry Learning Motivation Booster

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Abstract

Chemistry is widely regarded as one of the most challenging STEM disciplines for students pursuing further education in the science stream. Currently, the attrition rate in the field of chemistry is significant, despite the substantial impact that knowledge of chemistry has on enhancing our way of life. A strong inclination towards learning is crucial, as it will drive students to engage in passionate study and guarantee their perseverance in the subject. This study focuses on the effect of an intervention that combines innovation and chemical entrepreneurship on students' learning motivation in chemistry. To assess the students' level of enthusiasm to learn, a pre-test and post-test consisting of 25 statements were conducted before and after the module was implemented, with a two-month gap between the two tests. There were about 60 pre-university students who participated in this study, which used quasi-experimental design research. The data analysis revealed a statistically significant difference in the post-test scores between the treatment group ($M = 72.93$, $SD = 1.230$) and the control group ($M = 67.33$, $SD = 3.407$), $t(29) = 9.131$, $p > 0.05$ (two-tailed). An increase in learning motivation in the treatment group suggests that innovation and chemical entrepreneurship boost student engagement and interest in learning chemistry.

Keywords: Learning Motivation, Innovation, Chemical Entrepreneurship, Module, Chemistry.

Introduction

Chemistry is a science that studies matter, its properties, composition, and reactions at the atomic and molecular levels. It involves identifying materials and determining their composition using various analytical methods (Jesperson & Hyslop, 2021). Like other fields, chemistry contributes significantly to the progress of science, technology, and industry by developing new materials and technologies (Abolhasani & Kumalcheva, 2023; Baum *et al*., 2021). Chemistry helps humans analyse and solve problems related to the concept of chemistry and apply the knowledge gained through the advancement of science and technology. Chemistry is indeed capable of developing product production processing mechanisms that can not only improve the economy but also support global sustainability (Su & Cheng, 2019). This requires the involvement of innovation in the production of existing products widely and continuously in the industrial, financial, professional, and academic sectors.

Still, chemistry is often considered the most challenging science subject and is not widely chosen by students for university enrolment. In this context, the students' learning motivation is declining based on the percentage of students dropping out in the field at the university level (Bargmann *et al.,* 2021). Motivation is an internal factor that drives a person to maintain an optimal state of self to influence his or her behaviour and motivates him or herself to do something to achieve that desire (Rijanto & Iqrammah, 2019). Learning motivation is the nature of a strong desire or a strong spirit in a person that encourages an individual to try or do something with a purpose, to acquire knowledge and skills (Filgona *et al.,* 2020; Wardani *et al.,* 2020). Thus, learning motivation is an internal condition that evokes, directs, and sustains behaviours for learning. It is the driving force that pushes individuals to continuously seek opportunities for growth and development, even in the face of challenges or setbacks. This internal motivation plays a crucial role in shaping a person's attitude towards learning and their willingness to put in the effort required to achieve their goals. Thus, learning motivation is the key to unlocking one's full potential and realising their aspirations in both academic and personal pursuits.

Based on the previous studies at the post-secondary level, students with equivalent academic backgrounds but different learning motivations will show different learning outcomes and achievements (Rahardjo & Pertiwi, 2020; Steinmayr *et al*., 2019). High learning motivation is said to be a significant determining factor in the effectiveness of student achievement (Rafiola *et al.,* 2020; Zepeda *et al.,* 2020). In addition to the achievement aspect, learning motivation is also important in determining how much students will learn from learning activities or how much they will absorb the information presented to them. Students who are motivated to learn something will use higher cognitive processes in learning the material, so they will absorb the material better (Filgona *et al.,* 2020). For this reason, social factors have a big impact on students' motivation to learn. The pedagogical strategies and approaches that are appropriate to the instructional context can increase learning motivation among students.

In this context, the Self Determination Theory (SDT) explains the aspects of motivation required in the activities in the instructional module to be developed to increase students' learning motivation in chemistry. Introduced by Edward Deci and Richard Ryan (2008), SDT shows that the constructs in learning motivation can affect behaviour change, academic achievement, and learning outcomes of an individual (Rafiola *et al*., 2020; Ryan & Deci, 2024). According to SDT, extrinsic motivation is the drive to behave in a certain way based on external resources, and it produces external rewards. For example, the assessment system and awards. In contrast, intrinsic motivation comes from an internal drive that inspires us to behave in a certain way (Fishbach & Woolley, 2022; Ryan & Deci, 2024). The construct that influences the aspect of intrinsic motivation is autonomous motivation, while extrinsic motivation is the motivation that is controlled in influencing changes in students learning. When an individual is driven by autonomous motivations, they may feel directed and autonomous; when individuals are driven by controlled motivations, they may feel pressure to behave in a certain way and thus experience little or no autonomy (Ryan & Deci, 2024; Maddens *et al.,* 2023). Both intrinsic and extrinsic motivations are major contributors to the determination of our attitudes, and these two types of motivations, according to SDT, lead us to meet the three main basic needs of autonomy, competence, and relatedness, as shown in Figure 1.

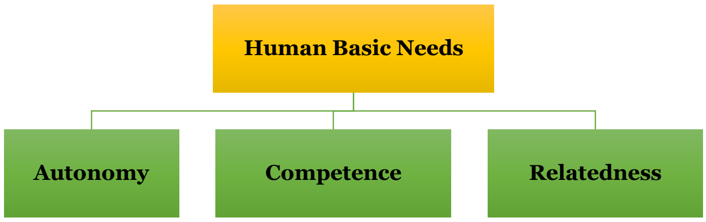

Figure 1. Human Basic Needs in Self Determination Theory

Autonomy refers to an individual's sense of self that he or she has at least control over his or her own life. Whereas competence is related to achievement, knowledge, as well as skills, and relatedness is when an individual has a sense of belonging, need for interaction and connection with others (Ryan & Deci, 2024). Fulfilling the three human's basic needs in SDT, is believed can improve someone's performance and achievement. Figure 2 briefly shown how the three basic need of humans contribute to the improvement in humans' achievement.

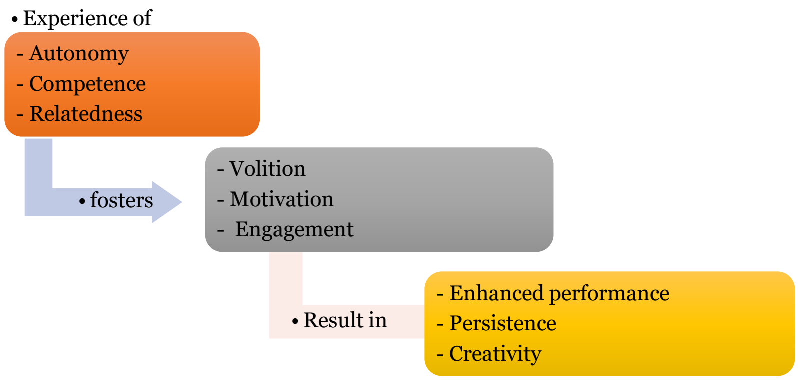

Figure 2. Self Determination Theory (Deci & Ryan, 2008)

How learning motivation affects achievement and performance has been explained through the findings of a study by Riswanto and Aryani, (2017), where high learning motivation was found to have influenced students in decision making, and increased their efforts during lessons**,** indirectly improving their performance in the achievement tests made. The main issue is how we'll meet these three fundamental needs for students during their educational experience, according to SDT. Undergoing critical and systematic literature studies, we found that through innovation, an individual or group of people is able to apply autonomy, competence, and relatedness to their learning experience. In investigating teaching approaches that can increase learning motivation among the sample, Prayitno *et al.* (2021) and Situmorang *et al*. (2018) found that students will show high learning motivation when involved in learning activities using the innovation element approach compared to conventional lessons in the classroom.

In addition to pedagogical diversity strategies, hands-on learning activities are one of the factors that increase learning motivation. Because when students are responsible for their innovation project and work together in a group, they will experience autonomy, competence, and relatedness. However, the instructional arrangement should be carefully and systematically planned so that the elements of innovation injected in the lesson are not too complex and relevant to the students' level of mastery of concepts. Innovation projects can also motivate students to learn, especially when they get reinforcement in the form of positive rewards. Satisfaction from completing the project, reward from the lecturer for their project, complement and attention given from friends, and people around are also kind of “positive reward”. The provision of reinforcement, whether positive or negative, i.e., in the form of rewards or punishments, can have a very large influence on students’ learning motivation. In the findings of past studies by Prayitno *et al.* (2021) showed that learning motivation among students was found to be increasing and persistent, even after treatment or intervention was stopped. Through the SDT, students who can relate the importance of learning a science will feel that the knowledge is meaningful, and this will increase their motivation to continue to learn and deepen the knowledge (Ryan & Deci, 2024).

As innovation can help in serving these three basic needs, why is there a need to integrate it with Chemical Entrepreneurship (CEP)? Well, CEP is a real-world context chemistry learning approach where students learn the process of processing materials into useful products with commercial value and develop entrepreneurship skills along the learning (Jaksch, 2021). The CEP approach lets the students learn how to produce a chemistry or chemical-based innovation product or service and process it as “sellable” (Fairusi *et al.,* 2020). In other words, they will learn how to commercialize their innovation. This is because it is much like problem-solving through design thinking but focuses on producing chemical-based products or involving the chemistry area (Sitompul *et al*., 2024; Situmorang *et al*., 2018). Previous studies have proven that CEP also helps in promoting students’ learning motivation, especially when the students realize the importance of chemistry through their innovation or product production. As such, a study from Sari (2019), which implemented CEP based in their lesson, successfully increased the learning motivation assessed through their engagement and persistence in chemistry, which improved their achievement test as well. Thus, the purpose of this study is to determine the effect of integrating innovation and Chemical Entrepreneurship through a learning module called i-CEP Module specifically on learning motivation towards chemistry.

Methodology

This study utilised a quasi-experimental design of treatment and control types using pre-tests and post-tests. This design was chosen over the true experiments because the selection process of study respondents could not be completely randomly distributed (Fan & Yu, 2017). Researchers in the past have often used the quasi-experimental design to find out how well a treatment works when the samples are incapable of being selected at random because of how the studies are run (Ah-Nam

& Osman, 2017; Creswell & Creswell, 2017). For example, students are in different classes, and the timing of treatment implementation is not simultaneous.

Since this study needed to determine the effect of innovation and CEP on students' learning motivation, a learning module integrating both innovation and CEP approaches (i-CEP Module) was developed. This i-CEP Module was used by a sample of 60 pre-university students at a college in Penang, Malaysia. In producing the innovation, this i-CEP Module proposes students to learn how to think outside of the box by controlling their psychological inertia, learn steps to produce innovation through combination problem solving steps from design thinking and Theory of Inventive Problem Solving (TRIZ), and then learn how to make their innovation "sellable" through CEP. One crucial step in the CEP process, known as the "define" step, involves assessing the marketability of innovative products. In this step, students need to identify and justify their functional innovation in terms of usability, uniqueness, targeted potential users, cost calculation and selling price estimation, and the intellectual property of their innovation.

In this study, Chemistry Learning Motivation Questionnaire (CLMQ) was used to measure pre-university students' learning motivation towards the chemistry subject before and after using the i-CEP Module. This instrument consisted of only one section of 25 items, which used a Likert scale. The instrument was developed and adapted from the Science Motivation Questionnaire (SMQII) by Glynn *et al.* (2011) and Glynn et al. (2009a & 2009b). Besides replacing the science subject with the chemistry subject, the instrument is also being translated into Malay. The validity of the CLMQ instrument was checked before undergoing reliability analysis on 30 students' samples, which have similar characteristics to the real sample. The reliability test was conducted during the pilot test phase. The CLMQ instrument showed a reliability value greater than 0.7, which is 0.95. Thus, it is reliable and can be used for the actual study.

The population in this study was 360 pre-university science students from a pre-university college in a state in northern peninsular Malaysia who are 18 years old and have moderate and low achievement (B+, B, B-, C+, C, C-, or D) in chemistry at their secondary level. Cluster random sampling was applied to choose which sample out of the 360 population of students with criteria listed. Based on a population of 360 people, out of 18 total classes, one is selected by the first ballot as the treatment group (N = 30), and a total of 1 class is selected by the second ballot as the control group (N = 30). So, the total sample used in this quasi-experimental research is only 60.

Since this study investigated the effectiveness of i-CEP Module which integrated innovation and CEP towards learning motivation, it included two main phases in the procedure. The first phase focuses on developing the module and conducting the pilot study. The second phase involved studying the impact of the i-CEP Module intervention on learning motivation. The students in the control group had undergone the conventional intervention, where they had to produce an innovation project by referring only to the rubrics, and they were free to choose their own problem-solving method. Previously, no specific method was employed. The treatment group will produce the innovation by using the method suggested by i-CEP Module.

Results and Discussion

The data collected was from both groups, which provided the score of the CLMQ pre-test and post-test and were analysed using Statistical Package for the Social Sciences (SPSS) version 26.0. Table 1 below shows the Likert scale mode frequencies of items in the CLMQ post-test for both the treatment and control groups. The Likert scale range score is from 1 to 5: (1=strongly disagree), (2=disagree), (3=neutral), (4=agree), and (5=strongly agree). From 25 learning motivation statements, there are five components: (1) intrinsic motivation (items 1, 3, 12, 17, and 19), (2) self-efficacy (items 9, 14, 15, 18, and 21), (3) self-determination (items 5, 6, 11, 16, and 22), (4) Grade Motivation (item 2, 4, 8, 20, and 24), and the last component, (5) Career motivation (items 7, 10, 13, 23 and 25). The minimum total score is 25 and the maximum total score is 125. The learning motivation level in this study are categorized into three main level, based on their scores recorded: High (100-125), Moderate (51-99), and Low (25-50). Item analysis according to their components in post-test for both samples (treatment and control) are shown in Table 1 below.

Table 1. Item Analysis of CLMQ in Pre-test

Statements (Items) Component	Mean		Standard Deviation (SD)	
	Treatment Group	Control Group	Treatment Group	Control Group
Intrinsic Motivation	22.23	17.53	1.478	2.315
Self-Efficacy	21.70	17.93	2.003	1.760
Self-Determination	21.77	17.07	1.524	1.639
Grade Motivation	22.30	15.80	1.622	2.483
Career Motivation	20.73	15.80	1.596	1.730

From Table 1, we found that both treatment and control groups have different learning motivations towards chemistry in all five (5) main components of the CLMQ test. The greater difference is in the grade motivation component. Where the mean score difference is 6.50. This shows that the treatment group shows greater motivation for grade achievement as compared to the control group.

For further analysis, we run the descriptive analysis and paired sample *t*-test to determine if there is any statistically significant difference between these two (2) groups of samples. Table 2 below shows the descriptive analysis for both the treatment and control groups.

Table 2. Descriptive Analysis of CLMQ

		Pre-test CLMQ Score Treatment Group	Pre-test CLMQ Score Control Group	Post-test CLMQ Score Treatment Group	Post-test CLMQ Score Control Group
N	Valid	30	30	30	30
	Missing	0	0	0	0
Mean (M)		68.73	67.47	108.73	74.90
Std. Deviation (SD)		4.034	3.665	6.539	4.596
Minimum		60	59	97	67

Maximum	74	74	125	84

From the descriptive analysis, we confirmed there was no missing data. The maximum score for both groups in the pre-test was similar, which was 74 (the total score of CLMQ), although there were differences in the minimum score recorded. In the post-test, there was a significant difference in the minimum score, which was 67 for the control group and 97 for the treatment group. We can also see that the increment in score in the treatment group is greater compared to the control group; the maximum score recorded for the treatment group is 125, whereas the maximum score for the control group is 84. From this mean score, we can summarise that in the pre-test, both groups showed moderate motivation as compared to the range stated before (moderate: 51–99). For the post-test, the treatment group mean score (M = 108.73) ranged as high (high: 100–125), whereas the mean score for the control group (M = 74.90) ranged as moderate.

To study the significant difference between these two groups, four paired-sample *t*-tests were done to determine the effect of integrating innovation and CEP through the i-CEP Module on students' Chemistry Learning Motivation. The four pairs are: (1) pre-test CLMQ score for both treatment and control groups; (2) post-test CLMQ score for both the treatment and control groups; (3) pre-test and post-test of the treatment group, and finally (4) pre-test and post-test of the control group. Table 3 shows the summary of the paired-sample *t*-test analysed.

Table 3. Paired-sample *t*-test of CLMQ

Pair	Mean (M)	Std. Deviation (SD)	Std. Error Mean	t	df	Sig. (2-tailed)
1	1.267	4.863	0.888	1.427	29	0.164
2	33.833	7.657	1.398	24.202	29	0.000
3	-40.000	7.316	1.336	-29.948	29	0.000
4	-7.433	4.960	0.906	-8.209	29	0.000

From the Table 3, the descriptive and paired-sample t-test of the CLMQ showed that there was no statistically significant difference in pre-test scores between the treatment group (M = 68.73, SD = 4.034) and the control group (M = 67.47, SD = 3.665), $t(29) = 1.427$, $p > 0.05$ (two-tailed). Then, to measure the effect size, the eta-squared statistic is determined. The eta-squared for this analysis was 0.06. This value indicated a moderate effect size, as suggested by Cohen (1988). Table 5 below shows the interpretation of eta-squared according to Cohen (1988).

Table 4. Eta-squared interpretation

Eta-squared value	Interpretation
0.01	Small effect size
0.06	Medium effect size
0.14	Large effect size

A large effect size means that the research finding has practical significance, while a small effect size indicates limited practical applications. For the second and third pairs, both, respectively, recorded a significant difference. In the second pair analysis, there was a statistically significant difference in post-test scores between the treatment group (M = 108.73, SD = 6.539) and the control group (M = 74.90, SD = 4.596), $t(29) = 24.202$, where $p > 0.05$ (two-tailed). The eta-squared indicated a large effect size, with an eta-squared value of 0.95. For the third pair, there was a statistically significant difference in the pre-test and post-test scores of the treatment group (M = 68.73, SD = 4.034) and (M = 108.73, SD = 6.539), $t(29) = -29.948$, where $p > 0.05$ (two-tailed). The eta-squared indicated a large effect size, with an eta-squared value of 0.97. Finally, for the fourth pair, there was a statistically significant difference in the pre-test and post-test scores of the control group (M = 67.47, SD = 3.665) and (M = 74.90, SD = 4.596), $t(29) = -8.209$, where $p > 0.05$ (two-tailed). The eta-squared indicated a large effect size, with an eta-squared value of 0.69.

From the results analysed, the treatment group was found to have a higher mean score in CLMQ compared to the control group, although they experienced an increment score from the respective pre-test. This result indicates that the i-CEP module, which integrates innovation and CEP, does contribute to enhancing treatment sample learning motivation as they go through the lesson activity in the module. As for the control group, although they also must produce an innovation product as a lesson project, without these two elements, innovation and CEP, they do not help much in enhancing their learning motivation. However, the study's shortcomings are related to the small number of students in the class. If there had been a large number, the outcome could have been solid. Future research could involve a greater number of students, as well as refining or adding factors to the coursework grade for better comparison and analysis.

Conclusion

A highly motivated student to learn chemistry will find that the concepts learned are meaningful to them. Thus, they will know the contribution and needs of chemistry in a real-life context, which makes them more interested in learning chemistry. This study also found that innovation and Chemical Entrepreneurship were well integrated into enhancing the students' learning motivation towards chemistry. However, there is a need to structure the lesson and curriculum in a more specific way to allocate and integrate both learning approaches systematically. More studies on how to plan the lesson must be conducted, so that will benefit both curriculum learning outcomes and students' learning motivation. Overall, integrating innovation and CEP approaches is not limited to chemistry but is used in a variety of courses to boost students' learning motivation and, as a result, their performance. It is intended that these well-balanced approaches be extended to other relevant courses to improve students' learning motivation and, eventually, their academic performance.

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the instrument to be downloaded (with permission and citation) by all researchers in Mary Frances Early College of Education, University of Georgia (Access link: Science Motivation Questionnaire II | College of Education | University of Georgia (uga.edu)).

References

Abolhasani, M., and Kumacheva, E. (2023). The rise of self-driving labs in chemical and materials sciences. *Nature Synthesis*, *2*(6), 483-492.

Ah-Nam, L., and Osman, K. (2017). Developing 21st Century Skills through a Constructivist-Constructionist Learning Environment. *K-12 STEM Education*.

Baum, Z. J., Yu, X., Ayala, P. Y., Zhao, Y., Watkins, S. P., and Zhou, Q. (2021). Artificial intelligence in chemistry: current trends and future directions. *Journal of Chemical Information and Modeling*, *61*(7), 3197-3212.

Bargmann, C., Thiele, L., and Kauffeld, S. (2021). Motivation matters: predicting students' career decidedness and intention to drop out after the first year in higher education. *Higher Education*.

Creswell, J. W., and Creswell, D. J. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (2nd Edition). In *Organizational Research Methods* (Vol. 6, Issue 3). http://www.amazon.com/Research-Design-Qualitative-Quantitative-Approaches/dp/0761924426

Fairusi, D., Hertanti, E., and Saridewi, N. (2020). Analysis of Creativity and Innovation Chemistry Education Students Through Chemo-Entrepreneurship-Oriented Product Assessment Model. In *Proceedings of the 5th International Conference on Education in Muslim Society, ICEMS 2019, 30 September-01 October 2019, Jakarta, Indonesia*.

Filgona, J., Sakiyo, J., Gwany, D. M., and Okoronka, A. U. (2020). Motivation in learning. *Asian Journal of Education and social studies*, *10*(4), 16-37.

Fishbach, A., and Woolley, K. (2022). The structure of intrinsic motivation. *Annual Review of Organizational Psychology and Organizational Behavior*, *9*(1), 339-363.

Glynn, S. M., Brickman, P., Armstrong, N., and Taasoobshirazi, G. (2011). *Science Motivation Questionnaire II : Validation With Science Majors and Nonscience Majors*. *48*(10), 1159–1176.

Glynn, S. M., Taasoobshirazi, G., and Brickman, P. (2009a). *Science Motivation Questionnaire : Construct Validation With Nonscience Majors Department of Mathematics and Science Education , 329 Aderhold , University of Georgia ,*. *46*(2), 127–146.

Glynn, S. M., Taasoobshirazi, G., and Brickman, P. (2009b). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*.

Hsieh, T. L. (2014). Motivation matters? The relationship among different types of learning motivation, engagement behaviors and learning outcomes of undergraduate students in Taiwan. *Higher Education*.

Jaksch, F. L. (2021). We Need An Entrepreneurial Culture in Chemistry: Do You Have What It Takes to be a Chemistry Entrepreneur?. *Chemistry Entrepreneurship*, 1-31.

Jespersen, N. D., and Hyslop, A. (2021). *Chemistry: The molecular nature of matter*. John Wiley & Sons.

Lai, E. R. (2011). Motivation : A Literature Review Research. *Research Reports*, *April*, 43.

Maddens, L., Depaepe, F., Raes, A., and Elen, J. (2023). Fostering students' motivation towards learning research skills: the role of autonomy, competence and relatedness support. *Instructional Science*, *51*(1), 165-199.

Meral, M., Colak, E., and Zereyak, E. (2012). The Relationship between Self-Efficacy and Academic Performance. *Procedia - Social and Behavioral Sciences*.

Prayitno, A. (2021). Model Pembelajaran Course Review Horay untuk Meningkatkan Motivasi dan Pengaruhnya Terhadap Hasil Belajar Produk Kreatif dan Kewirausahaan. *Jurnal Pendidikan Indonesia*, *2*(12), 2069-2081.

Rafiola, R., Setyosari, P., Radjah, C., and Ramli, M. (2020). The effect of learning motivation, self-efficacy, and blended learning on students' achievement in the industrial revolution 4.0. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(8), 71-82.

Rahardjo, A., and Pertiwi, S. (2020). Learning motivation and students' achievement in learning english: A Case study at secondary school students in the covid-19 pandemic situation. *JELITA: Journal of English Language Teaching and Literature*, *1*(2), 56–64.

Rijanto, T., and Iqrammah, E. (2019). Motivation Measurement model to Learn Basic Buliding Construction and Survey Engineering using Confirmatory Factor Analysis. *Jurnal Pengukuran Psikologi Dan Pendidikan Indonesia (JP3I)*.

Riswanto, A., and Aryani, S. (2017). *Learning motivation and student achievement : description analysis and relationships both*. *2*(1), 42–47.

Ryan, R. M., and Deci, E. L. (2024). Self-determination theory. In *Encyclopedia of quality of life and well-being research* (pp. 6229-6235). Cham: Springer International Publishing.

Sari, D. K. R. (2019). *Pengembangan Modul Pembelajaran Kimia Berpendekatan Chemo- Entrepreneurship (Cep) Pada Materi Hidrolisis Garam Bagi Peserta Didik Kelas Xi Di Man Kendal*.

Sitompul, H. S., Situmorang, I., and Tuty, T. (2024). Sustainability Learning: Project Based Learning Integrated Chemo-Entrepreneurship Approach to Understanding Chemistry and Interest in Entrepreneurship. *Jurnal Ilmiah Global Education*, *5*(2), 1355-1361.

Situmorang, M., Sinaga, M., Purba, J., Daulay, S. I., Simorangkir, M., Sitorus, M., and Sudrajat, A. (2018). Implementation of innovative chemistry learning material with guided tasks to improve students' competence. *Journal of Baltic Science Education*.

Steinmayr, R., Weidinger, A. F., Schwinger, M., and Spinath, B. (2019). The importance of students' motivation for their academic achievement-replicating and extending previous findings. *Frontiers in Psychology*, *10*(JULY).

Wardani, A. D., Gunawan, I., Kusumaningrum, D. E., Benty, D. D. N., Sumarsono, R. B., Nurabadi, A., and Handayani, L. (2020). Student learning motivation: a conceptual paper. In *2nd Early Childhood and Primary Childhood Education (ECPE 2020)* (pp. 275-278). Atlantis Press.

Zepeda, C. D., Martin, R. S., and Butler, A. C. (2020). Motivational Strategies to Engage Learners in Desirable Difficulties. *Journal of Applied Research in Memory and Cognition*, *9*(4), 468–474.