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## The Involvement of Gender in STEM Training for Teachers

Duc Hoi Dinh

Thai Nguyen University of Education, VIETNAM

Quang Linh Nguyen\*

Thai Nguyen University of Education, VIETNAM

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**Abstract:** According to General Statistics Office of Vietnam on 30th September, 2017, Vietnam has 858,800 teachers, and among those, 615,720 people were female (occupied 71.7%). It can be seen that female teachers made up a big percentage in the education sector. Besides, STEM education is soaring as a new approach in training with prominent advantages, such as: theories embedded in actual practices, ability-oriented development, pressure reduction in studying ... This is not only a trend but also a necessary element in new teaching modules at high school – which will be implemented in academic year 2020-2021 in Vietnam. As a result, it is necessary to consider the gender factor in the process of training and developing teaching with STEM education. This paper will present the results from the research that took place from 2015 to 2018 within Thai Nguyen University of Education.

**Keywords:** *STEM, STEM education, teachers training, integrated teaching.*

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### Introduction

#### *STEM Education and Gender*

STEM Education has successfully proved that it would have develop strongly in any education system and in any country in the world, with the attention from the governors, administrators, scholars, educators, teachers, and learners. While STEM has become such an important part of the world's education, a gender gap has started to appear in STEM - related fields. "Even when females perform as well as or better than their male peers on STEM related tests or projects, females lose interest at higher rate and do not pursue advance courses, majors, and careers in STEM" (Reinking & Martin, 2018). Also Leaper (2014) supposed that there are some "outside factors, such as parents, courses, teachers, and society" that "influence likes and dislikes for gender, which is known as gendered socialization". Reinking & Martin (2018) has proposed several solutions for the gender gap in disciplines, such as combatting assumed and historically rooted stereotypes by improving community's knowledge, creating equality in education, telling and spreading stories of females in STEM industries, creating STEM movements for girls and women... It was found that,

Some believe the gender gap is a direct response to stereotypes and socialization practices in the United States and other countries focused on male dominance and female submissiveness. Supporting the idea of socialization and societally engrained stereotypes also focuses on the gender socialization practices that occur in childhood such as boys are smart in Maths and girls are good in the kitchen. These socialization practices feed into the concept of stereotype threat, which can undermine girls' performance in STEM fields (Reinking & Martin, 2018, p.149).

"Other researchers believe that the gender gap is not necessarily due to socialization and stereotype threat practices. Some believe the gender gap in STEM is directly linked to the role peer groups play in the academic experiences of students" (Crosnoe, Riegler-Crumb, Frank, Field & Muller, 2008) or females often deal with much more difficulties than males in pursuing and working in STEM-related fields (The Business Review, 2017, para 7). Kerpen (2017) confirmed that despite accounting for nearly 60 percent of all college graduates in the U.S., women earn only 18 percent of degrees in computer science and engineering and 35 percent of degrees in STEM overall. According to her, only when females believe and invest in themselves, and constantly learn, grow, and embark on new challenges..., can they have more chances in STEM related fields.

#### \* Correspondence:

Nguyen Quang Linh, Thai Nguyen University of Education, Vietnam. ✉ [nguyenquanglinh@dhsptn.edu.vn](mailto:nguyenquanglinh@dhsptn.edu.vn)



In an article published in 2018, Gijsbert Stoet stated that there was an “underrepresentation of girls and women in STEM” in comparison with males. Although this percentage is different from country to country, countries with higher level of gender equality actually are witnessing an increase in the gender gap. And, in order to improve the status, several proposals are outlined, like more attention for girls’ and women’s education, or gender equality should be advocated and promoted (Gijsbert & David, 2018).

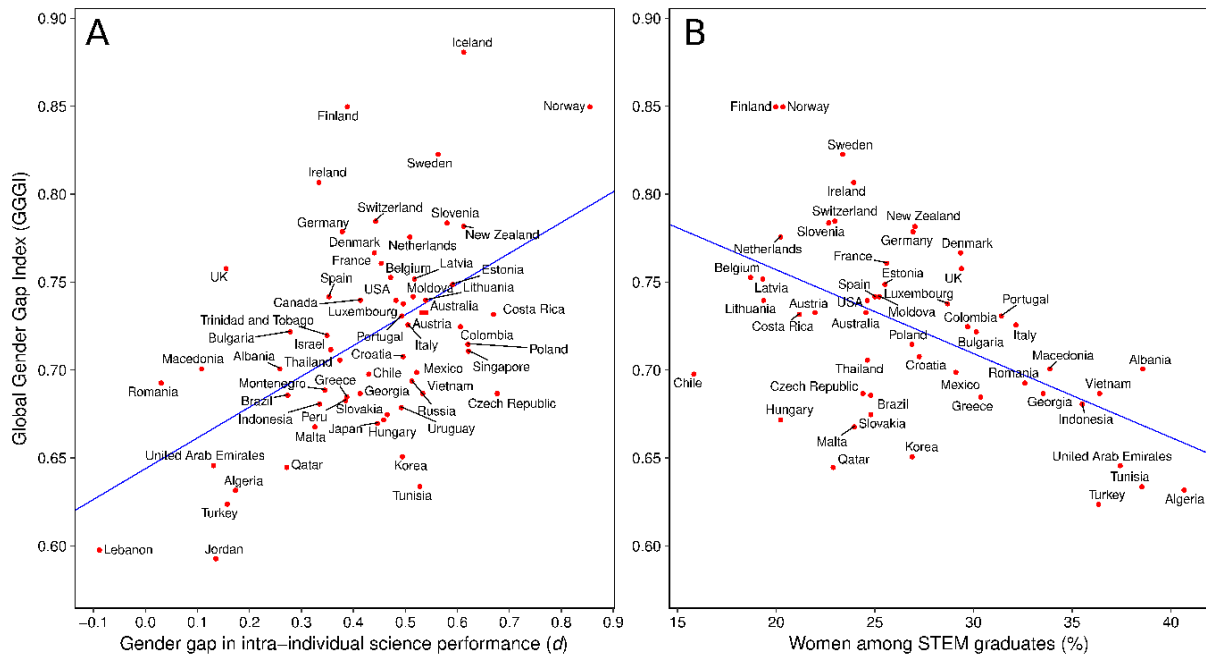


Figure 1: Gender equality (y-axes) is related to sex differences in intra-individual science strength and STEM graduation.

The Global Gender Gap Index (GGGI) assesses the extent to which economic, educational, health, and political opportunities are equal for women and men. Blue lines indicate the regressions. A: The gender gap in intra-individual science scores was larger in more gender equal countries ( $r_s = .42$ ). B: The percentage of women with degrees in STEM fields was lower in more gender equal countries ( $r_s = -.47$ ).

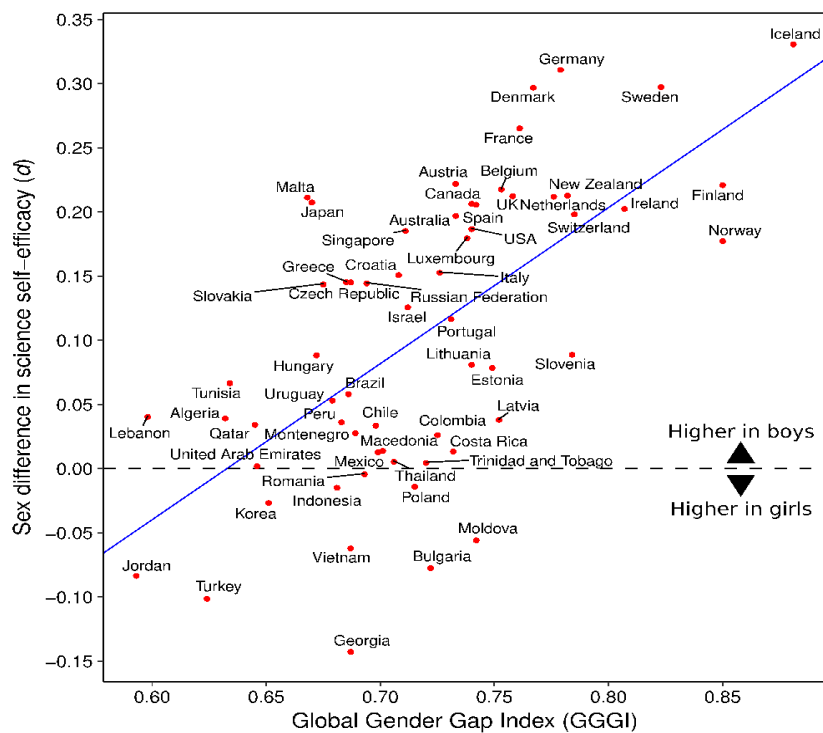


Figure 2: Sex differences in science self-efficacy (y-axis) increase with increases in the global gender gap index (x-axis).

According to General Statistics Office of Vietnam (2019), among about 1.8 million students nation-wide in 2016, there were 934.500 females (accounting for approximately 52%). However that may not be the percentage of the students in

STEM-related industries, which saw a great inequality in males and females, and for some special industries, the number of males is about 2.5-to-4.0-time higher than that of females. Nowadays, although Vietnam is still one of the countries with the lowest gender equality, the number of women scholars working in STEM fields is quite high compared with that of the world (as in Figures 1 & 2), we still have to find solutions to expand the proportions (Gijsbert S. & David C.G., 2018).

#### *STEM Education & Vietnamese new K12 Textbooks*

In the new K12 textbooks series launched in Vietnam period from 2012 to 2022, STEM Education was emphasized in the statement by Prof. Dr. Nguyen Minh Thuyet – Chief Editor of new K12 textbook series: *“Developing STEM Education in the new textbook series is indispensable because the objectives of STEM Education are right the one the new textbook series aim at.”* (Youth, 2018). The new K12 textbook series has indicated:

Together with Maths, Natural Sciences, Information Technology and General Technology all together help promote STEM Education, one of the most effected educational trends that have attracted great interest from educators and scholars in many countries in the world and in Vietnam as well.” (Ministry of Education & Training, 2017, p. 30).

Vietnam new K12 textbook series which started in July 2017 and the curricula of the subjects which were published in December 2018 indicated that the content of the STEM-related subjects has been paid more attention to and designed with more activities (STEM activities). The STEM orientation can be seen as: (1) New K12 textbook series consists of all STEM subjects: Maths, Natural Sciences, General Technology, Information Technology, Physics, Chemistry, and Biology; (2) The position and the role of Information Technology and General Technology have been enhanced significantly, which is not only a proof of STEM education, but an adaption of Vietnamese K12 education in the era of 4.0; (3) Many modules and topics in Maths, Natural Sciences, General Technology, Information Technology, Physics, Chemistry, Biology are designed following STEM orientation. (Ministry of Education & Training, 2017 & 2018).

General Technology is supposed to *“have close relationship with many other educational fields, especially Maths and Sciences. Together with Maths, Natural Sciences, the subject of General Sciences help promote STEM education – one of the trendiest educational trends in the world.”* This is also presented in other STEM subjects like Biology, Chemics, or Information Technology (Ministry of Education & Training, 2018, p. 33). As for the objectives of the subject General Technology following STEM education, the main topics of the subjects are Technical Craft Group (Primary School), Designing Technical Group (Secondary School), Optional Module (Grade 9), Design and Technology Group (High School), and Integrated Study Group. STEM topics in foundation training periods of integrated programs are Natural and Social Sciences, Sciences, Information Technology and General Technology (in Primary School), Natural Sciences (in Secondary School). The ideas of renewing education methods that are stated in the new K12 textbook series are suitable with STEM orientation at the level of integrated teaching strategy, or applying multi-subject knowledge to solve the practical problems... (Youth, 2018).

Natural Sciences subject is supposed to *“integrate STEM education into teaching to develop students’ ability of integrating knowledge and skills of natural sciences, technology, techniques, maths to solve several realistic situations”* and *“together with Maths, Technology and Information Technology, the subject of Natural Sciences helps promote STEM education – one of the most conspicuous trend not only in Vietnam, but also in the world – to meet the needs of young labour recourses in the modernization and industrialization of the country”* (Ministry of Education & Training, 2018, pp. 33 - 34).

For Mathematics, it is stated that

Maths in high school contributes to the formation and development of key qualities, general competencies and mathematical competencies for students; it helps develop key knowledge and skills and creates opportunities for students to experience and apply mathematics to practice, or creates a connection between mathematical ideas, between Mathematics and practice, between Mathematics and other subjects like Sciences, Natural Sciences, Physics and Chemistry, Biology, General Technology, and Information Technology, and between Mathematics and other educational activities to implement STEM education”. Furthermore, *“Maths program focus on applicability, integration with reality or other subjects and educational activities - especially those which help implement STEM education; it is in line with the modern development trend of economy, sciences, social life and urgent global issues (such as climate change, sustainable development, education and finance...”* (Ministry of Education & Training, 2018), p. 47).

Other descriptions of STEM education in Physics, Chemistry or Biology are similar to those in Maths, General Technology or Natural Sciences. Thus, it can be said that STEM education is an indispensable element in the new general education program in Vietnam. This means that the universities of pedagogy in Vietnam need to train teachers who can teach STEM subjects. In pedagogical universities in Vietnam, female students often account for a large proportion. When there are some specific requirements for those teaching STEM subjects, there is surely a barrier between STEM and

female students, which has caused a concern about the training of female students in STEM subjects at pedagogical universities.

### **Methodology**

#### *Target group*

The participants of the research are both male and female students studying in a variety of faculties – mostly STEM-based ones like Mathematics, Physics, Chemistry and Biology in Thai Nguyen University of Education. They are supposed to be teachers in high schools after graduation.

#### *Research question*

For the female students who would become STEM teachers in high schools in the future, the difficulties they have to deal with is not a joke. This reality becomes a motivation to do the research, trying to answer the question: “Should we pay any special attention to the training of female STEM teachers in Vietnam?”

By answering the research question, the study will help evaluate the ability of designing and organizing experimental activities between male and female students in finishing STEM tasks. Together with this, the researchers would like to check if we should spend more time training the female students or not.

#### *Methods of Inquiry*

This quasi-experimental research was done with students studying in Physics, Chemistry and Biology Faculties in Thai Nguyen University of Education from 2015 to 2018 to decide whether the female students need specific help during their studying in the university or not. “A quasi-experimental research is research that resembles experimental research but is not true experimental research. Although the independent variable is manipulated, participants are not randomly assigned to conditions or orders of conditions” (Cook & Campbell, 1979)

During the training course, design ability and experimental activities organization skills had been developed following STEM education orientation (the results of the research has been published in the article “Fostering the capacity of designing and organizing experiential learning activities for students majored in natural science of pedagogical universities in the orientation towards stem education” by (Nguyen, 2019) in Vol. 163, Issue. 8, 2019 of SYLWAN journal.

The research was designed to conduct in 6 steps: [1] Gather ideas on grouping STEM tasks → [2] Divide the class into groups based on students’ ideas → [3] Perform learning tasks → [4] Evaluate the task performance of groups → [5] Collect feedbacks from students → [6] Make conclusions.

The data of the research was collected from the answers for a survey questionnaire of the students who participated into the training course as well as the research. The data then were analyzed following statistical method.

### **Research Findings**

#### *Experimental Process*

The research had been done in 03 periods, with total 255 people taking part in (Tables 1 & 2). They were all students studying in different STEM-based faculties in Thai Nguyen University of Education. During the experimental process, the research group organized 02 STEM orientation activities: 01 was to foster designing ability, and 01 was to organizing skills for experimental activities (These annual activities had been done in Thai Nguyen University of Education based on the students’ needs. And the students’ needs are the results of another survey done from 2014 to 201 by the administrators of Thai Nguyen University of Education.). Each class is supervised by 01 or 02 lecturers, trained from 6 to 7 days (constantly or interruptedly).

Table 1: Sessions, Subjects, &amp; Numbers of learners participating in the experiments

No.	Sessions	Subjects	No. of students	No. of teachers	No. of classrooms
1	12/5 to 30/7/2016	4th-year students majored in Physics, Chemistry, Biology (Course 48)	42 students (7 groups; 9 boys)	3	1
2	13/2 to 28/5/2017	3rd-year students majored in Physics, Chemistry, Biology (Course 49)	206 students (32 groups; 44 boys)	7	5
3	28/5 to 15/8/2018	4th-year students majored in Physics, Chemistry, Biology (Course 50)	217 students (35 groups; 43 boys)	7	6

Total: 465 students; 7 lecturers

Table 2: Classification of students in experimental activities training course

No.	Groups	Session 1	Session 2	Session 3
1	With 01 only/ Without male students	5	22	27
2	With 02 & more male students	1	5	8
3	With 03 & more male students	1	5	0
Total		7	32	35

When gathering ideas on grouping, the researchers gave out 5 choices: [1] Single sex only, [2] Equal number of males vs. females, [3] Randomly, [4] Faculty-based, and [5] Other preferences. The results of the issue “how the students think about the needs of having male students’ supports in the groups’ activities” are presented in Figure 3.

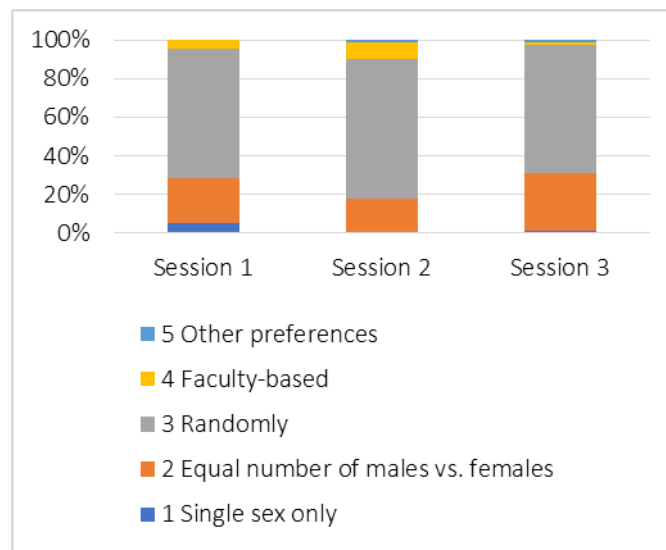
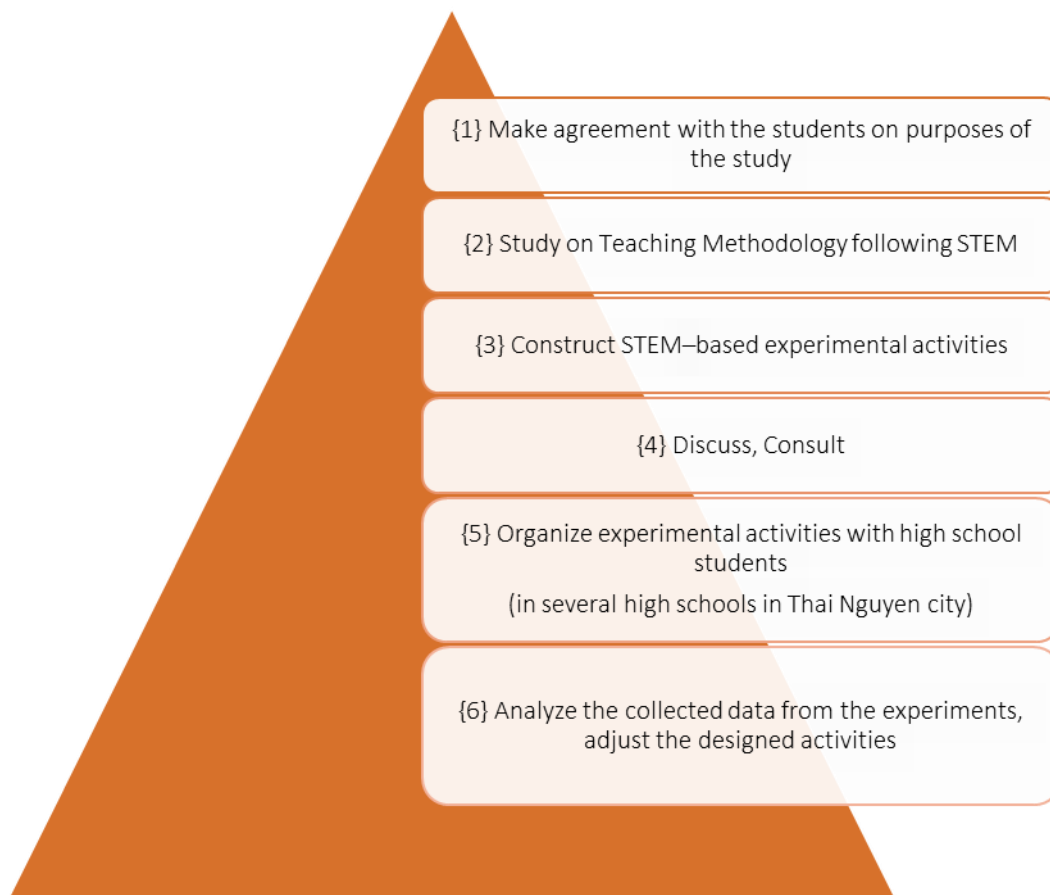


Figure 3: Students' preference on grouping

From the results above, in the Session 1 and 2, the students were divided into groups randomly (according to alphabet order of the students' names). The Session 3 was special when the students were divided into groups so that the numbers of the males and females were equal (at the highest level if possible) although most students preferred the random division. The purpose of the change in ways of dividing students into groups is to check the differences in ability to fulfill the tasks of the students.

In the Step 3, each group was given a certain task (depending on the Session). Basically, Step 3 consists of several substeps:



*Diagram 1: Substeps of performing learning tasks*

In the first and second substep of Step 3, based on a holistic rubric assessment of the students' STEM products, the researchers realized that there was no difference between the working of males and females. However, it was in the third minor step that the students need to choose 01 experimental activity following STEM education. In this period, the selection the activity of the students was based on students' experiences or the strengths of the students in the group. Therefore, gender may be considered as one of the elements which affects the students' selection of STEM activity content that they had to design and organize for high school students. This is the reason why the researchers decide to study on the effects of gender on the STEM task selection, as well as the results of performing tasks in the minor step 5.

#### *Experiments Results*

- Evaluate the students' preference on grouping

The 2019 survey estimates that about 71% of high school teachers are women (Vietnam General Statistics Office, 2019, p. 14). However, the total number of the students attending pedagogical universities has decreased significantly, which then affects the average percentage of male and female teachers in the future. The number of the male and female students majoring in Physics, Chemistry, Biology and Maths in Thai Nguyen University of Education participating in 03 Sessions organized by the research group (including Course 48, 49 and 50) is illustrated in Chart 2. This number is equivalent to the number of the male and female students attending the training courses of the design ability and the organization of experimental activities following STEM (with females accounting for 80%).

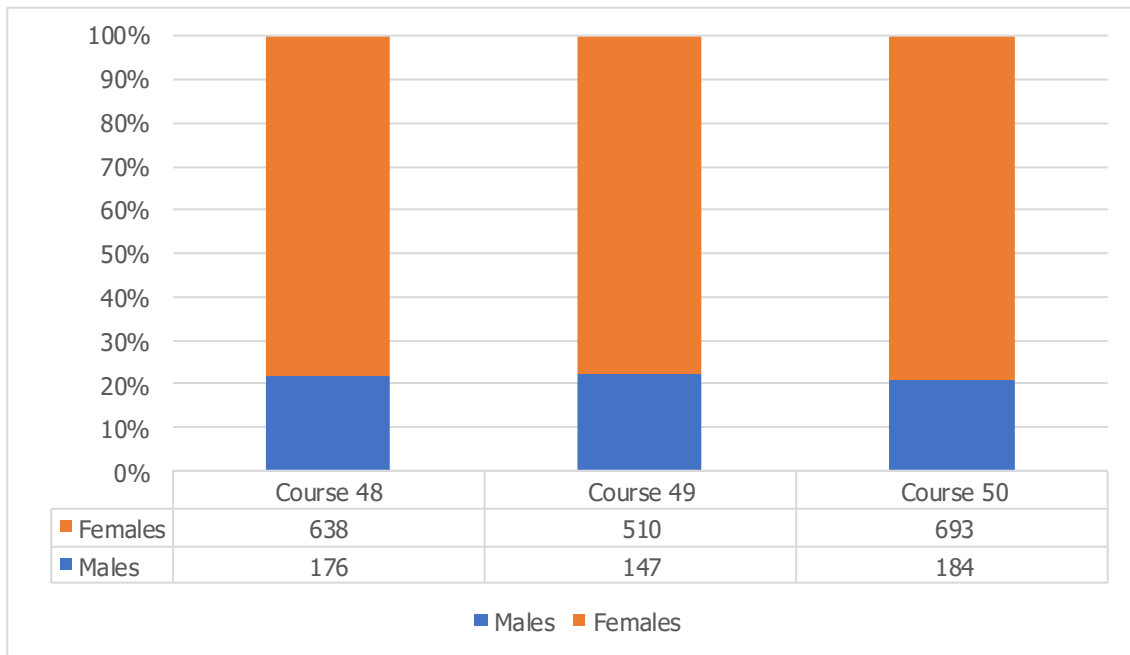


Figure 4: Males vs. Females in Physics, Chemistry, Biology, Maths Faculties

From the collected data of students’ preference on grouping before STEM tasks (Figure 3), the researchers had checked whether their preferences of grouping are different or not. They focused only on 02 major choices which are [3] Random Division and [2] Equal Division (with the same percentage between males and females) (Figure 3). The results are presented in Figure 5.

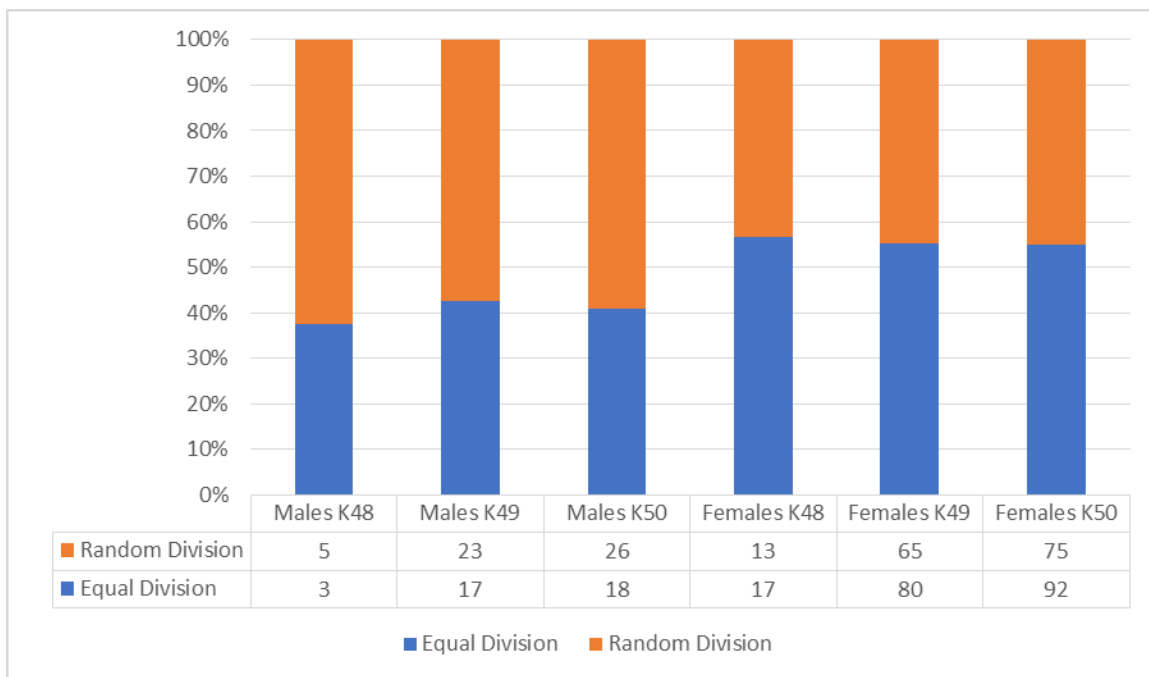


Figure 5: Students’ ideas on grouping with gender

From that, it is easy to see that males seem prefer Random Division, with high percentage (about 60% depending on each training course), whereas females prefer Equal Division for both males and females with the percentage of about 57% depending on each course. The researcher supposed that the students’ perception on the ability finishing tasks or the ability supporting each other in doing tasks between males and females are differences. And female students had shown great desire on males’ supporting during doing tasks. Through the questionnaire, female students expressed their preferences of grouping with males, whereas it is OK for male students to join any kind of grouping, either males only or mixed. For trainers of this special course, during training and coaching, grouping is always taken much care of, so as to guarantee the balance as much as possible the rate of males and females in each group, and the balance of that rate between groups. And this is not only for this course, but it is also applied to all the lecturers and a variety of courses on a regular basis.

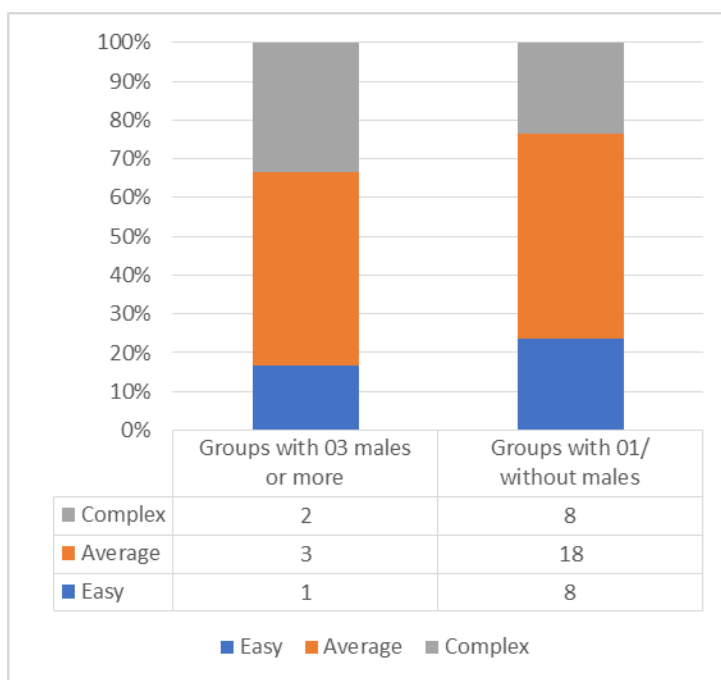
- Evaluate the differences between the task selection’s complexity in the third minor step in Step 3

To evaluate the complexity of the production that the students chose to design and organize for high schools’ students, the researchers construct a checklist of criteria as in Table 3.

**Table 3: Criteria to evaluate the complexity of the tasks**

No.	Criteria	Score Point	Lecturer’s Score
1	The difficulty in perfecting production (The more complex the STEM production is, the higher the marks are.)	3	
2	Time to organize the activities (the longer the activities are, the higher the marks are.)	3	
3	Difficulties in organization process (The more difficult the activities are, the higher the marks are.)	4	
Total		10	

Each criterion in Table 3 are divided into several levels, each level is equal to the increase of 01 point. For example, the second criterion is divided into 03 smaller parts: Level 1 – Organization time equal to a period of lesson (45 mins) (01 point is the highest point); Level 2 – Organization time equal to 02 periods of lesson (02 points is the highest); Level 3 – Organization time equal to 03 periods of lesson (03 points is the highest). The total score of the groups is evaluated in 4 levels: Very Easy (04 or less), Easy (4,1 – 6,0), Average (6,1 – 8), Complex (8,1 – 10).



*Figure 6: Complexity level in student tasks’ duty*

The researchers aimed at finding whether there are differences or not in the task selection’s complexity level in STEM duties between Groups with 01/ without males and Groups with 03 males/ more. The results are presented in Figure 6. From that we can see Groups with more males tend to choose more complex duties compared with the other groups. However, these differences are not clear.

- Evaluate the results of groups’ mission completion

Design ability and organizing experimental activities ability following STEM orientation are evaluated in 03 scores: observation checklist (a), self – assessment table (b) and peer assessment table (c). Then the final score of the learner is

$$x = \frac{a + b + c}{3}$$

calculated according to the following formula: . The observation checklist is built with the criteria as shown in Table 4, self-assessment scores and peer assessments in Table 5, each criterion is evaluated up to 2 points. These criteria are agreed with the students before conducting the training course. The capacity observation checklist is provided for volunteers, each volunteer is responsible for monitoring and evaluating 01 group. Self-evaluation and peer evaluation boards are distributed by each teacher at the end of the learning process (Nguyen, 2019).





Figure 3: Students conducting study mission (A: Group discussion on planning for the duty; B & C: Organizing STEM activities for students in high schools)

Table 4: Observation checklist for designing & organizing abilities of experimental activities

No.	Criteria	Highest scores	Evaluate scores
1	Succeed in designing STEM-oriented experimental activities as guided	2	
2	Succeed in organizing experimental activities in high schools	2	
3	Be able to evaluate high schools' students during their participation into the activities	2	
4	A working process report	2	
5	Q&A; Class contribution	2	
<b>Total</b>		<b>10</b>	

Table 5: Self-assessment & Peer assessment

No.	Criteria	Highest scores	Evaluate scores
1	Group contribution	2	
2	Gather ideas of group members and other groups	2	
3	Plan activities together	2	
4	Be active in group activities	2	
5	Feedback about group's activities & members' activities	2	
<b>Total</b>		<b>10</b>	

The scores to assess the design capacity and the organization skills of experimental activities for students are quite similar in 3 forms (self-assessment, peer assessment and observation checklist). This shows that the assessment tools designed are reasonable and highly reliable. The final assessment results of the students are divided into 5 levels: Weak, Poor, Average, Good and Excellent with 2 points in 10-point scale and are considered from two angles: The scores of male and female students (Figure 7); and the score of the groups with few male students and the groups with many male students (Figure 8).

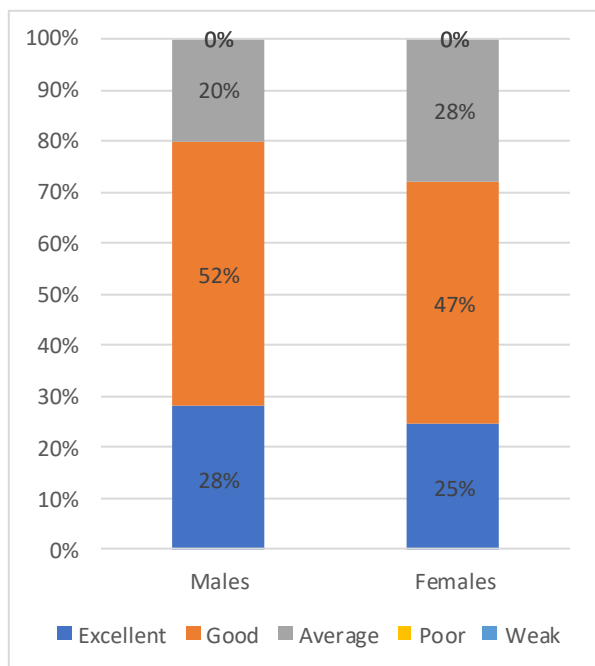


Figure 7: The evaluation results of the design capacity & experimental activities organization skills

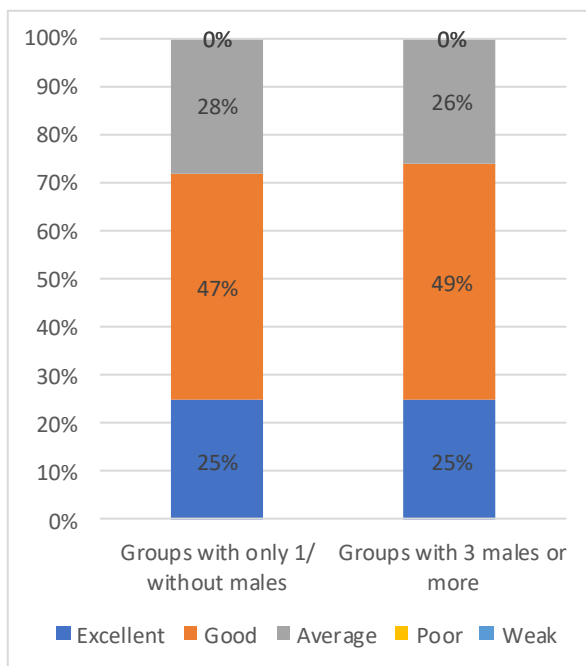


Figure 8: Classify the design capacity & experimental activities organization skills in groups

The results showed that the portion of the female students with high marks is smaller than that of males, yet not too much. This is similar in evaluating the design capacity and the experimental activities organization skills in group, when the results of groups with 3 males or more are higher than those of the groups with more females. Notwithstanding, while analyzing the experimental process, the researchers saw an exception of 01 group with all 07 female members who got the highest score of all. This is a proof for that females can and surely can work as well as, or even better than, males in completing STEM missions.

### Conclusion

While movements and curricula are striving to combat the reality that there is a gap between males and females students in the ability to implement STEM missions, “the mentalities and embedded socialized constructs need to be questioned and changed. However, it is also important to remember that, while there is a gender gap, girls have been entering the STEM field at an increasing rate over the last twenty years.” (Reinking, A. & Martin, B., 2018)

As for teaching students in Pedagogy schools, for students who choose STEM fields majors, there are still barriers in their own awareness about their ability to complete STEM jobs. In reality, female students can do well the jobs that sometimes, the society or even the females themselves think that only male students can do well. This was proved strongly again when answering the questions in the questionnaire, female students expressed that they would like to participate in the groups with males, while male students’ answers showed that they can participate in any random group. Facilitators should pay attention to encourage female students more in the process of working, helping them to have more confidence in themselves. Because if they have confidence, female students can complete STEM tasks as well as male students. However, attention should still be paid to the division of study groups so that the male / female ratio is as balanced as possible. In fact, pedagogical schools should also have their own attention (maybe specific courses) for female students studying in STEM fields so that they can complete their studies well. These are also factors that help reduce gender inequality in society. When female students graduate, they will be role models for female students to succeed in STEM fields. But it is also important for us not to allow gender inequality to turn in the opposite direction, because gender equality is not a “women issue”.

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