AGENT-BASED SIMULATION FOR UNIVERSITY STUDENTS ADMISSION: MEDICAL COLLEGES IN JORDAN UNIVERSITIES

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ABSTRACT

Medical colleges are considered one of the most competitive schools compared to other university departments. Most countries adopted the particular application process to ensure maximum fairness between students. For example, in UK students apply through the UCAS system, and most of USA universities use either Coalition App or Common App, on the other hand, some universities use their own websites. In fact, a Unified Admission Application process is adopted in Jordan for allocating the students to the public universities. However, the universities and colleges in Jordan are evaluating the applicants by using merely the centralized system without considering the socioeconomics factor, as the high school GPA is the essential player their selection mechanism. In this paper, the authors will use an Agent Based model (ABM) to simulate different scenarios by using Netlogo software (v. 6.3). The authors used different parameters such as the family-income and the high school GPA in order to maximize the utilities of the fairness and equalities of universities admission. The model is simulated into different scenarios. For instance, students with low family income and high GPA given them the priority in studying medicine comparing with same high school GPA and higher family-income, as a results, after several rotations of the simulation the reputation of medical schools are identified based on students' preferences and seats' allocated as it shows that high ranking universities are mainly allocated with have high cut-off GPA score.

KEYWORDS

ABM, Netlogo, GPA, UCAT, Medical Colleges, Jordan, Simulation, Agents

1. INTRODUCTION

Universities across the world are working hard to compete with other universities globally to attract and host students into their campuses, however, quality of education is varying from institution to another, as it depends on multiple of factors such as the quality of teaching, the experience, the environment, and others. Thus, schools and colleges should keep up with the state-of-the-art in technology in order to compete with others effectively (Assayed et al., 2023). Medical colleges are the most competitive colleges in universities to get into with high grades demanded [2,3]. The distinguished high school students with high GPA are usually intended to study medicine [4]. In fact, medical schools have limited seats for students, and top universities required top students, thus, most medical colleges required high criteria in terms of high school grade as well as other admission tests such as AP, BMAT, UCAT, etc. In general, countries have their own policies in admitting students, some universities have a centralized admission, and others depend on university' rules. For instance, some universities can allow the disadvantaged applicants to define themselves and explaining their socioeconomic status by writing a supplementary essay [5]. On the other contrast, others apply the need-blind admissions policies which students are evaluated based only on their merit without considering their financial status. Medical colleges in Jordan are evaluating the applicants by using a centralized system without

considering the socioeconomics factor, as the high school GPA is the essential player in the selection mechanism, the final scores of high school is evaluated based on final twelfth grade, and usually high schools have two streams of education: Scientific and Theoretic streams, accordingly the Ministry of Higher Education (MOE) in Jordan deployed some centralized criteria for specific majors, for example the applicants to medical and dental schools should graduate from scientific stream with minimum score is 85% [6], However, according to MOE the cutoff score in year 2022 for less selective medical schools is reached (93.5 %) comparing to (98 %) in the most selective universities. Indeed, the fairness and equality are essential in the admission process since some disadvantaged students with limited income need to be considered into this process, thus thousands of students apply yearly through a unified admission system in order register to universities in Jordan and any incorrect update in this procedure might have a negative impact to the students as they could jeopardize their admissions into universities. Therefore, the Agent Based model (ABM) can be used to simulate different scenarios before deploying any update into the unified admission system and this paper aims to contribute by having an effective simulation in the unified admission environment which both the students and medical colleges are interacting together. This model will be simulated by using different policies in terms of considering the family-income and the high school GPA in order to maximize the utilities of the universities admission fairness. This paper is organized as follows: Section 1 explore the related works, section 2 describes the methodology in this research, section 3 explains the results and the conclusion and future works are described in section 4.

2. RELATED WORKS

Several researchers raise their concerns about the fairness in university's admission and as a result computation models are developed such as the agent-based model which can simulate different scenarios of students and universities' s admission behavior. However, the medical schools particularly are not mentioned in any of the previous works. However, this review described a variety of models which used different universities admission's scenarios from different perspectives.

Leoni [7] developed an agent-based model for simulating the factors that can affect students' decision to study undergraduate degree in Italy. The world in this model is selected from surrounded families such as friends and colleagues in the same community.

The author specified two main agents which are the Junior agents and the Senior agents and are defined as the following:

1- Junior agents: Agents that are completed the secondary education and they have two options either studying at universities or dropping out.
2- Senior agents: Agents that are in the labor market and they might be skilled or not, it depends if they went to college or not.

However, the junior agents select to enroll into the college if they get influenced by their and in each tick of the simulation the junior agent observes the neighbors of the seniors' agents. The author used the NetLogo platform as multi-agent environment for simulating the data to better translate the real world's environment.

The model simulated in three different scenarios based on students' preferences to admit at colleges, which are summarized as the following: 1- the future income 2- The impact of the influences of their neighbors and colleagues 3- the students' determinations to complete the college.

In fact, students and schools in (K-12) are attracted by the researchers to develop agent-based model to support students for interacting with schools. They can select the best that can maximize their utilities, Díaz et al. [8] simulated a model by using the Netlogo, the authors created the world with students and schools as it simulated the schools in Santiago city- Chile, attributes are defined as students' income, the location of schools, and schools' achievements as shown in Fig1.

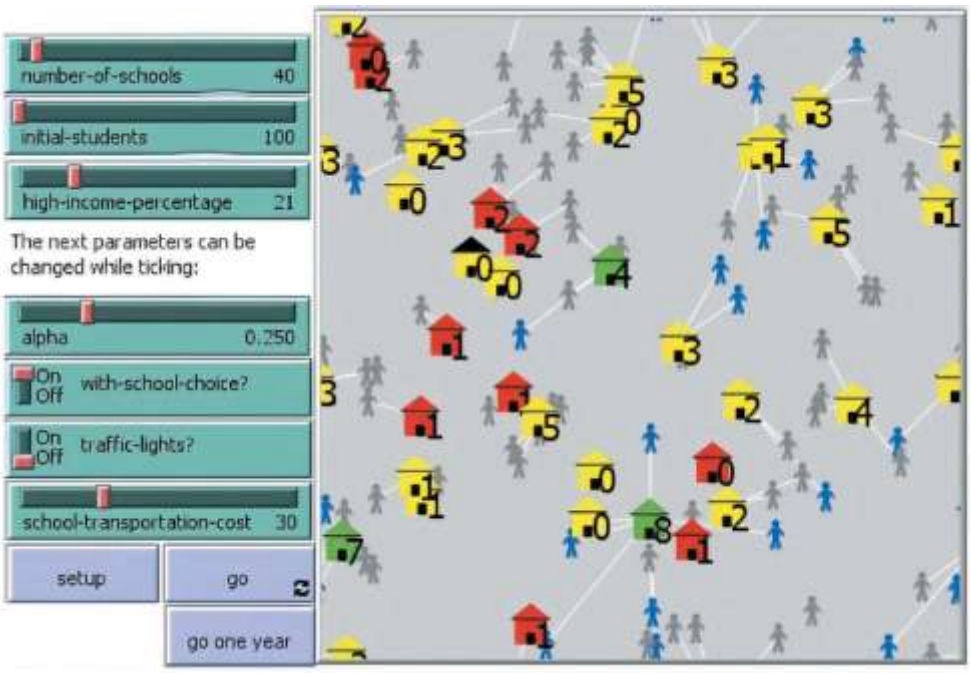

Fig 1. The world of the model of the students and schools

The main objective of this model, is to understand the students' behavioral in terms of schools' selection, different factors are considered for example the family income, school's performance, location and the type of schools. The model is executed by using different scenarios for instance when the school choice is turned on the result displays that students with high-income are joining schools with high performance and accordingly their schools' average will be increased as shown in fig 2.

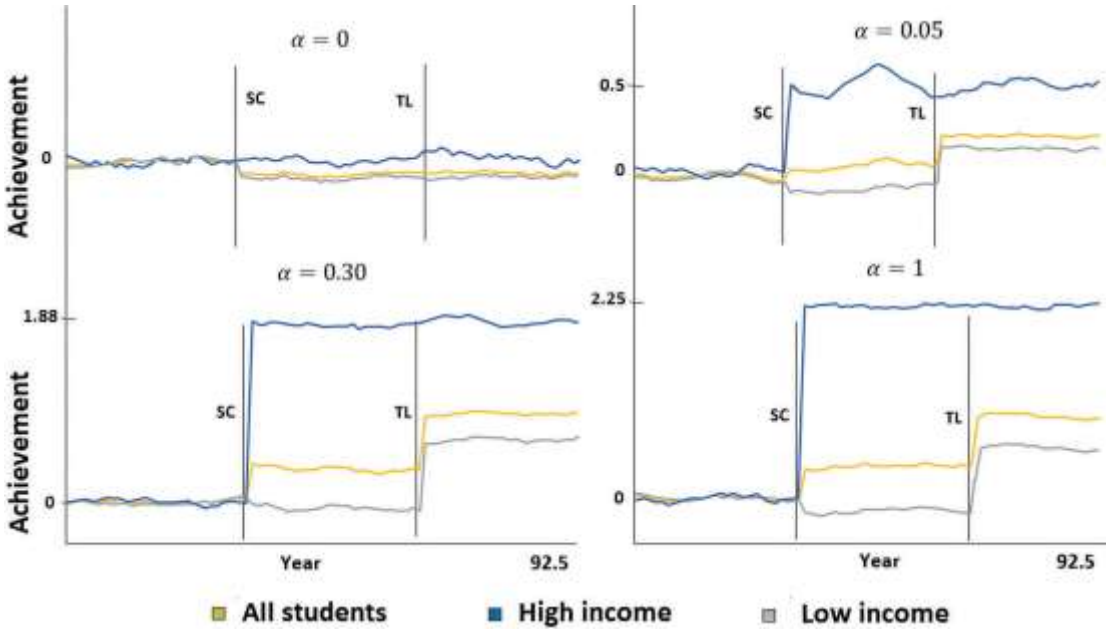

Fig 2. Students' average performance based on students-income

Reardon et al. [9] simulated an ABM for universities' sorting process which aims to understand the students' behaviors that can influence the sorting of selecting the colleges. The authors used two major agents: students and colleges with interacting together into three stages: 1- Students' applications 2- Students' admission 3- The enrollment. Fig 3 explains the four stages of the agent based simulation.

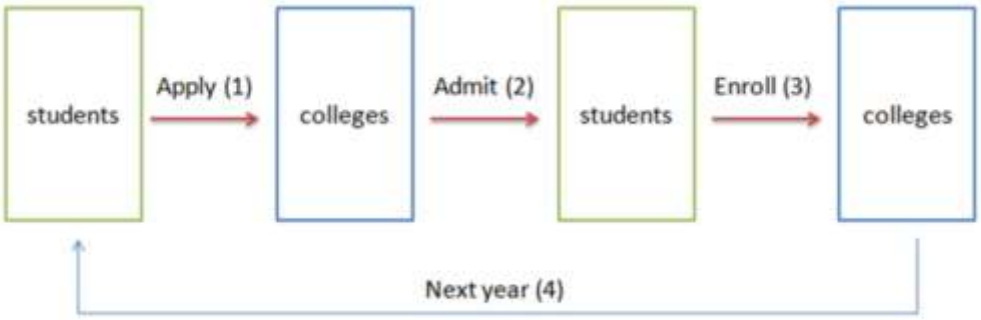

Fig 3. The three stages of the agent-based simulation.

Though, the model connected the socioeconomic features with other factors such as the college sorting and college fees. Students in this model can register in high ranking universities, and these universities can select students based on their performance of SAT/ AP. Subsequently, the authors execute the simulation 100 times in order to reach to the inspected parameters with the minimum biases.

Bhatia, et al. [10] developed an ABM by using the NetLogo to allocate seats for prospected students based on students' preferences. Students and universities are indicated as agents. Though, the universities defined the cutoff-grades of admission for each particular course, and this cutoff depends on the previous admissions for each university based on the high-school average.

The simulation executed in two scenarios: 1-Partially-centralized admissions 2- Fully-centralized admissions. The partially process all schools decide their own cutoff scores of high-schools for each major. Alternatively, the fully-centralized scenario each college will assign the seats for the applicants only one time after the results are released from high schools as depicted in Figure 4.

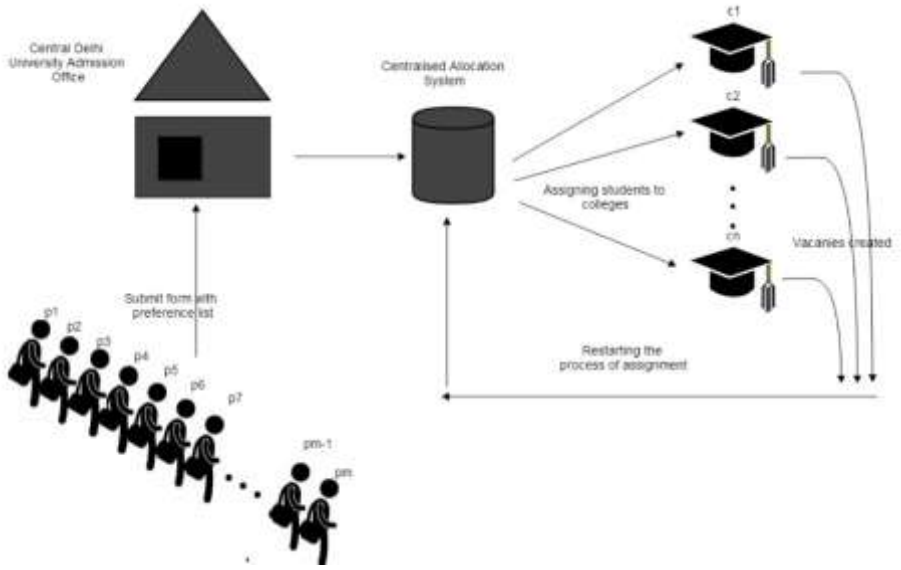

Fig 4. The centralized admission process of universities-admission.

However, the results show that the most interested colleges to the students might not have the highest cutoff-grades, as the cutoffs average are generated based on universities' experiences.

Furthermore, Hou, et al. [11] examined a simulation in Mongolia of China for matching the college admission in order to have more fairness admission system, students would be able to work together for manipulating the admission mechanism, students with high GPA can change the selected university through the admission system before the end of the deadline, accordingly the new slot will be opened automatically for a new prospected student with lower grade. The authors use real time interactive-mechanism by using the ABM in multi stages to study the students' manipulation behavior during application real-time processes. The ABM defined two agents: 1- student as indicated by N= (1,2,3,..n) 2- Universities which denoted by S=(s1,s2,s3,….sm), however, the quota of admission in each university is defined by Q = (q1,q2,…qm) ,moreover the preferences of students in selecting the universities is denoted by P = (p1,p2,..pn), the strategy of this manipulation's process will depend on the minimum average between the two manipulations students (score diff), the student can hold the seat for low score's student only if the difference between both scores is larger than the (score-diff). Yet, the simulation runs in (T) rounds, and every student has one chance to submit his/her application, and everyone should define the general information of preferred university, for example the university's ranking, cutoff average and the seats' quota, then the manipulation students with high average will be able to apply to the universities that accept low averages, on the other hand, low-score students will apply to the matched-universities before the (seat-transfer-time), the simulation will show the behaviors of the students with high score that release the seat to the low-score's students based on their preferred list and accordingly the high-average students will apply to the preferred university. Fig 5 shows the performance of the model. Large percentage of students choose to implement the manipulation process, which can end it up with distributing the fairness between students.

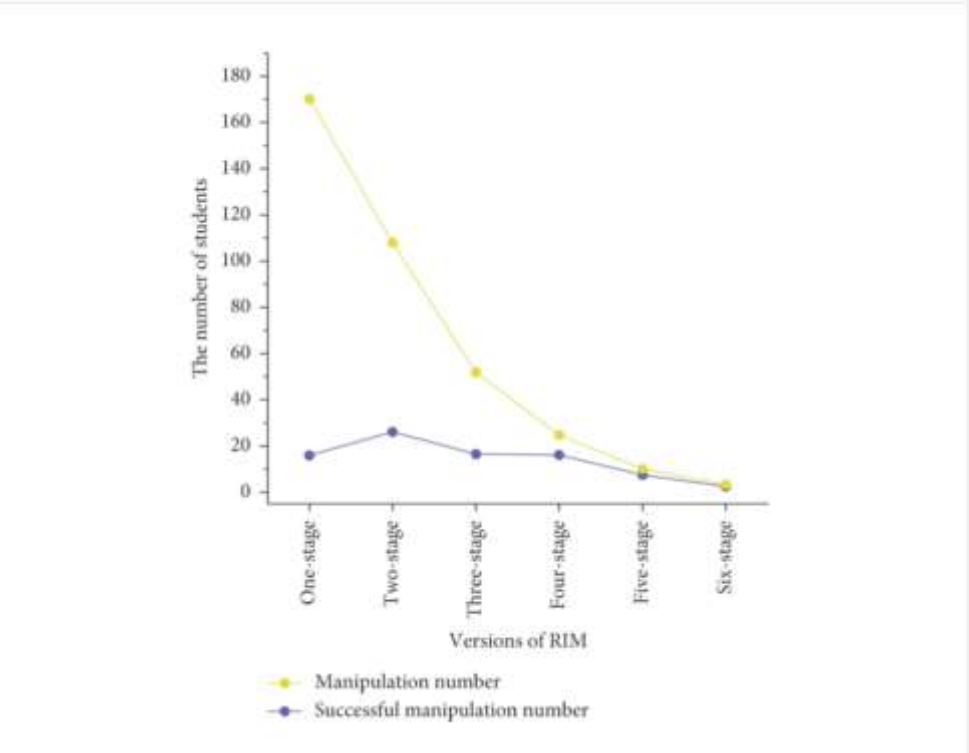

Fig 5. Large percentage of students who choose to implement the manipulation process.

Furthermore, Reardon et al. [12] simulated a dynamic model to study the behavior of the socioeconomic-status in particularly the affirmative action policies on students' enrollment choices, applying the affirmative action in colleges and universities can have impacts on increasing the chances of the disadvantaged & under represented students by paying more attention to them for admitting them into top colleges. The simulation used 40 colleges & universities and 150 students. The number of seats is specified to 6000. The model applied to only four racial groups: 1-White 2- Black 3- Hispanic 4- Asian. The simulation model rotated three stages in each single year, however, the results show that applying affirmative action's policies by universities can reduce the diversities of the type of the admitted students comparing to other colleges that are not applying these polices.

3. METHODS

3.1. Initiating the Model

The author studies the behaviors of students' admission in medical schools by using agent based simulations and different scenarios are implemented in order to examine the degree of fairness in admission. We used a NetLogo 6.3 as open source platform to simulate our model, the simulation is initiated by defining two type of agents as the following:

- First agent: High School Students
- Second agent: Medical Colleges

The first agent is denoted by number of students (n) and their grades in high school is generated randomly by the system, the second agent is the number of medical colleges and it's indicated by (m), and both are interacting together, as the students interact with the colleges in order to maximize their utilities and get the preferred seats, different attributes are assigned to the agents, for example the number of students and the number of the seats in each college are defined by the users, on the other hand, the high school grades, preference list and family income are generated randomly from the system as illustrated in table 1.

Table 1. The attributes that are assigned to the student's agents.

Student's agent Attributes		
Attributes	**Definition**	**Data generation**
High school grade	The high score of students in grade 12 (100 % percentage)	Randomly
Family income	The yearly family income of students	Randomly
Preference List	The students 'preference on selecting the medical colleges	Randomly

On the other hand, the medical colleges behaviors would be affected by the number of colleges, students as well as the quota of seats in each college as depicted in table 2. Therefore, in this simulation we have an option to adjust the number of medical schools in order to study the behavior of universities admission while the number of students applicants is constant.

Table 2. The Parameters that controlled by users

Parameters that controlled by users		
Attributes	**Definition**	**Data generation**
The number of students candidates	The students who are competing to enroll at their preferred medical colleges	Defined by the users, we selected first scenario with sample 15 students, and second scenario with 45 students.
The number of Medical colleges	The number of colleges that are matched with students' preferences	Defined by the users, we got two scenarios, first one having 4 colleges with capacity 3 seats each, and others having 4 colleges with intake 6 seats capacity.
The quota of seats	The assigned number of seats for each colleges	Defined by the users. Each scenario we can change the quota in order to study the students and universities' behavior.

Fig 6 shows the set-up environment in 16 x 16 coordinates with 15 students and four medical colleges. The high school average is mentioned as well for each student.

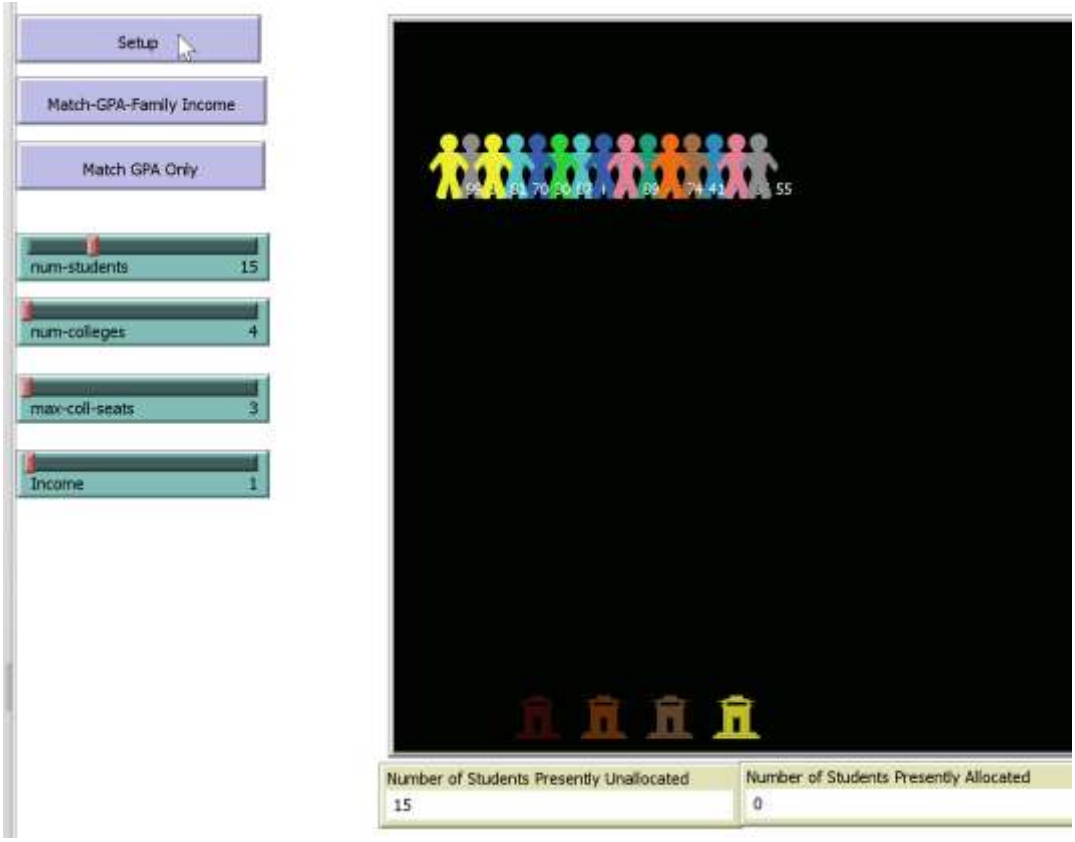

Fig 6. The set-up environment in 16 x 16 coordinates with 4 colleges and 15 students.

3.2. ABM' Implementation and Analysis

The Matching function will assign the students based on mainly the high school average as well as the family-income in order to ensure the fairness among all prospected students.
The model runs by matching each prospected student to the medical colleges based on different scenarios:

1- Each college has a limited number of seats which defined by users.
2- The users will select the number of colleges as well as the number of prospected students.
3- Students with high school average will be matched to their college's preference immediately.
4- Afterward, the next student will be checked if his preference's college is the same as the first one, then the quota of seats for this particular college will be checked, if there is a space in the college, the student will have matched accordingly to the college, otherwise will be matched to second college in his preference's option
5- If there are more than one student have same high school average and both are targeting the same 1st preference list; the family-income's factor will be checked and consequently the student with lower- family income will have the priority to match him to the preferred college.
6- Different rotations will be evaluated in this simulation to examine the best scenario for maximizing the utilities for students and universities -with considering the low-family income students-.

7- Afterward, the environment will show students in red, those who not allocated to any colleges even though the preference list is still not empty.
8- If the preferences options all over without allocating to any colleges then students will be changed to gray color as shown in figure 7.

3.3. Finding and Discussion

Fig 7. The simulation shows the students allocation to the colleges

When we increased the number of students to 45 with 6 seats in each four colleges the results show that 31 of the students are not allocated as the priority goes to students with high school GPA and low- family income, as we can see in Figure 8 that 31 students have low GPA and are not qualified to be admitted in the colleges.

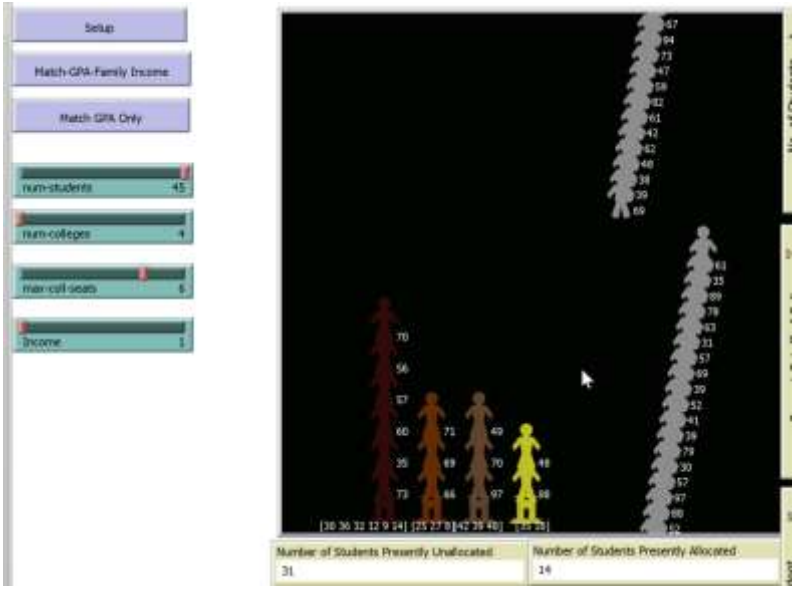

Fig 8. Increasing the number of students and considering the factor of family-income

On the other hand, when we considered the factor of family-income we can see in figure 9 that the number of unallocated students are decreased. Students- income can vary from students to another, and changing the level of family income can affect students' allocations in universities.

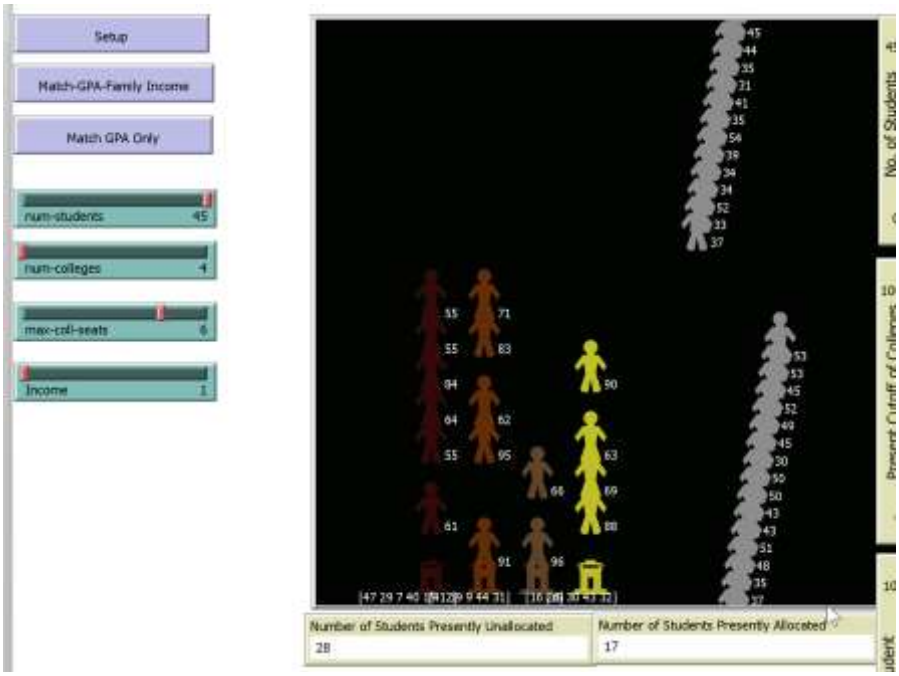

Fig 9. The effect of the factors of family-income in the unallocated students

The family-income variable is added as a slider input in order to simulate in the model with keep other variables/factors (number of students, number of seats, number of colleges) are constant. Afterward we keep changing the amount of students-income. Figure 10 shows the allocations after changing the family-income as it shows the quality of students are not allocated the same as before. The first college selected more students and the cut-off score is 81, which indicates the

most competitive medical schools. The reputation or the ranking of the medical schools are measured by the number of colleges that have matched to the students as first preference option, after running the simulation into different rotations it reveals that reputations are measured with institutions that have the maximum number of high scores in HS as depicted in Figure 11

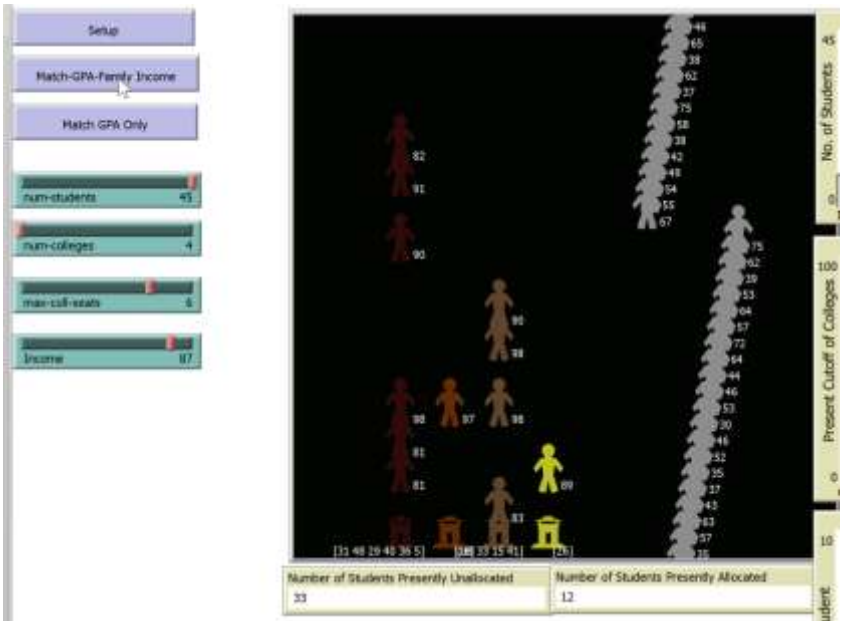

Fig 10. The allocations after changing the family-income.

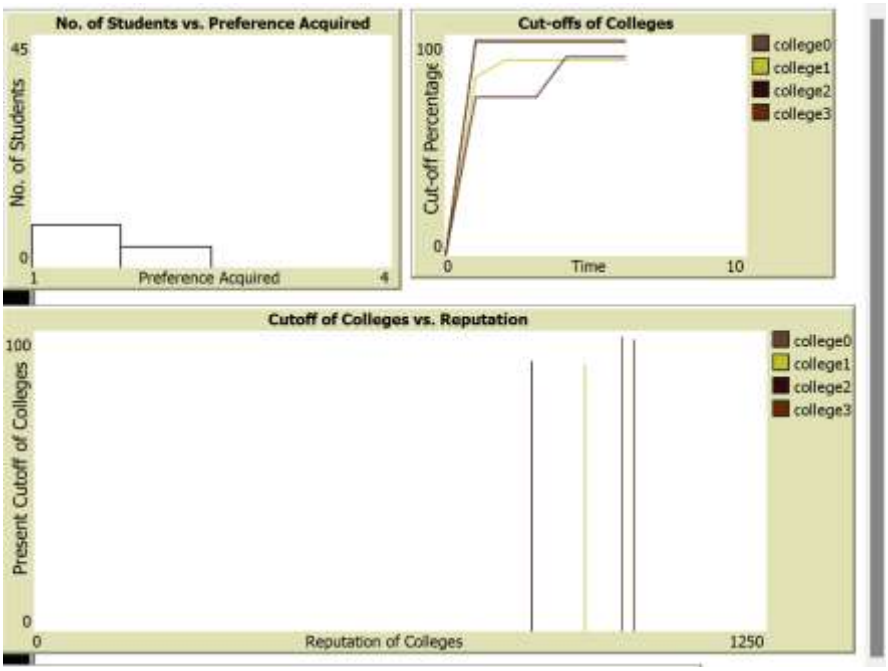

Fig 11. The reputations are measured based on the institutions that have the maximum number of high scores GPA.

4. CONCLUSION AND FUTURE WORK

There are many students around the world from different socioeconomic background are thrilled to get admitted into medical school's program, However, medical schools are very competitive comparing to other majors. Hence, the academic factors play a vital role on students' admission, for instance the high school GPA, and other admission tests such as SAT, IB, AP, BMAT, UCAT need a good preparation in order to pass it successfully. The disadvantaged students with need-based would not be able to afford the cost of attending a preparation classes or having any private tutors. Therefore, the purpose of this simulation is to consider the family income besides the high school GPA in allocating the medical schools seats between all students including the disadvantaged students. Students with low family income and high GPA will give them the priority in studying medicine comparing with same high school GPA, and higher family-income, as a results, we can promote the equity and fairness between the prospected students from different socioeconomic background.

This simulation explains the behaviors of students' admission in medical schools by using agent based simulation. The Netlogo 6.3 is adopted as an effective open platform for simulating this model. The simulation is initiated by using two agents: The high school students and the medical colleges. Several rotations are tested by keep changing different factors such as number of students, number of seats, and family-income. Afterward, the simulation reveals the importance of considering the factors of family- income in allocation students' seats in universities' admission. Moreover, the simulation illustrated the reputation of the medical colleges by showing these colleges are allocated to the students with high school's GPA since the students as well selected these colleges in their first preferences list. This study will add a contribution to the researchers and developers especially for those who are interested in using state-of-the-art technology in enhancing the education. In future, other scenarios will be implemented in this simulation with adding a standardized admission tests such as TOEFL, IELTS, or SAT.

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