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Assessment Tool for Environmental Attitude of Students in Higher Education Institutions

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More institutions of higher education are striving to become sustainable organizations. Overall environmental attitude of an institution is a reflection of collective behavior of different campus constituents. This paper explores the feasibility of the usage of Agent-Based Modeling (ABM) as a tool to understand how such collective behavior of one of the constituents, students, can emerge from individual local interactions. ABM is a bottom-up method that explores the connection between local interactions and the collective behavior. For that reason, it is critical to develop an interaction rule that reflects on the way a student actually meets with other students. Actual student profile data gathered at Universitat Politècnica de València (UPV) is used as a validation tool. This preliminary model gives insight on the nature of the sensitivity of the students' receptiveness for accepting/rejecting information and also the initial distribution of students' awareness level on environmental concerns required to achieve a sustainable campus. A unique, novel and intuitive modeling method to assess changes of the campus environmental attitude is provided. The methodology has also the ability to provide insight by conducting a series of bottom-up "what if" simulations to understand the causes that define the level of environmental attitude of campus.

Keywords: Agent-Based Modeling; Environmental management system; Behavioral change; Environmental attitude; Students; Bottom-up method

Una herramienta para la evaluación del comportamiento ambiental de estudiantes en instituciones de educación superior.

El comportamiento ambiental de una institución es un reflejo del comportamiento colectivo de los diferentes componentes del campus. Este artículo explora la viabilidad del uso del modelado basado en agentes (ABM) como una herramienta para entender cómo el comportamiento colectivo de uno de los componentes, los estudiantes, puede surgir de las interacciones locales individuales. ABM es un método ascendente que explora la conexión entre las interacciones locales y el comportamiento colectivo. Por esa razón, es fundamental desarrollar una regla de interacción que refleje la manera en que un estudiante conecta con otros estudiantes. Datos reales del perfil de los estudiantes de la Universitat Politècnica de València (UPV) se utilizan como herramienta de validación. Este modelo preliminar da una idea de la naturaleza de la sensibilidad de los estudiantes a la aceptación / rechazo y la distribución inicial del nivel de conciencia ambiental de los estudiantes requeridos para lograr un campus sostenible. Se proporciona un método de modelado único, novedoso e intuitivo para evaluar los cambios en el comportamiento ambiental del campus. La metodología también tiene la capacidad de proporcionar una visión basada en simulaciones "de abajo hacia arriba" para entender las causas que definen el comportamiento ambiental del campus.

Palabras clave: *Modelos basados en agentes; Sistemas de gestión ambiental; Cambios de comportamiento; comportamiento ambiental; estudiantes; método ascendente*

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1 Introduction

Universities are concerned with environmental, social and economic aspects of campus management, and they are motivated to promote an effective practice of sustainability. A sustainable campus is an institution that promotes and practices sustainability with its community within and beyond the physical limits of the campus. (Van Weenen, 2000; Velazquez *et al*, 2006). Practicing campus sustainability, however, often requires a behavioral change of individuals of the campus community. For example, recycling of waste materials will not be truly effective unless a majority of the student population consistently separate and collect the waste in the designated bins. If a student is accustomed to throwing everything in the trash bin unsorted, then he needs to make a conscious effort to separate the waste and collect it in the desired fashion. Effective promotion of sustainability requires a coordinated effort from the environmental, economic and social areas of campus management.

Environmental concerns are usually raised and managed by a campus environmental office that implements policies through an Environmental Management System (EMS) whose function is to provide a set of guidelines to identify environmental concerns and monitor the continued progress. However, the implementation of a policy does not always result in a rapid increase in the students' awareness of the environmental issues, as in the case of waste recycling. It is thus essential for the EMS to implement a policy that encourages students to comply with it and help make the campus more sustainable. This process, however, still ultimately depends on the choices each student makes. Therefore, a new tool is needed that can help the environmental office assess the level of the students' awareness on particular environmental issues and develop a strategy to increase the awareness level of the students. In addition, since the awareness level often changes as the result of the interactions of a student with other students, there is a need of a new modeling tool that allows us to assess a collective behavior based on local interactions (Kaiser *et al*, 1999).

There are several distinct constituents making up a campus community: students, professors and researchers, administrative and service personnel. Each constituent has a unique set of attributes that influence the collective behavior of the organization (Torregrosa-López *et al*, 2016). In this study, where a general framework of a model has been built, students have been selected as the only constituent. Previous research has consistently shown that the level of the environmental attitude among students is positively related to the environmental behavior of the campus community as a whole (Bamberg, 2003; Kaiser *et al*, 1999). Thus, the ability to understand the evolution of the level of environmental attitude of campus community members can help us improve environmental performance more effectively. This paper presents a modest beginning of the modeling efforts of this research group by first understanding the behavior of the largest group of campus constituencies: the students.

In this paper, a unique but particularly well-suited method called Agent-Based Modeling (ABM) is introduced. ABM is a bottom-up modeling technique that can give insight into collective social behavior emerging from local interactions among individuals. It also allows the combination of social and environmental parameters to describe the evolution of a collective behavior without compromising the complex nature of interactions (An, 2012; Hare and Deadman, 2004; Pullum and Cui, 2012). ABM has been applied to the management of natural resources, waste management, land use and other relevant areas as the project management (Hsu, S. et al, 2016).

The assessment of the university's environmental performance based on the promotion of pro-environmental attitude of students is possible with an ABM model, where the level of environmental attitude manifests as the result of interactions of students with different attributes and environmental knowledge. Previous studies showed a strong correlation between the level of environmental knowledge and the environmental attitude of individual students (Brick et al., 2017, Kaiser et al., 1999, Grob, 1995). The environmental knowledge may be assessed by surveys over a representative population on campus. For this paper, necessary data are provided by the EMS at the Universitat Politècnica de València (UPV) which shows the environmental performance of the university. The environmental performance of UPV can be used as a case study to determine and eventually validate the proposed ABM model.

The goal of this paper is to describe a simple ABM model developed, describe how to validate it, and then present preliminary results to help understand how the environmental attitude of students affects the environmental performance of the campus.

2 Description of Agent-Based Model (ABM)

A university campus houses students, administrators, professors/researchers and support staff. They exchange opinions among themselves. In order to understand how a decision-making process is influenced through the exchange of opinions towards environment, a tool is needed that can capture how opinions are exchanged locally and how exchanged opinions become a collective opinion.

ABM is a simulation technique that allows to investigate phenomena where individual students interact under certain rules. For this preliminary study, the students at UPV are the only agents. ABM connects local interactions of individual students to an emerging global behavior of the university. ABM can be applied to a wide range of complex phenomena that occur in the areas of political, social, economic and environmental concerns. Societal decision-making processes are particularly well-suited for the ABM (Macal and North, 2010). There are several ABM software available but NetLogo (Wilensky, 1999) is the one chosen for its ease of use and high level of parameter control.

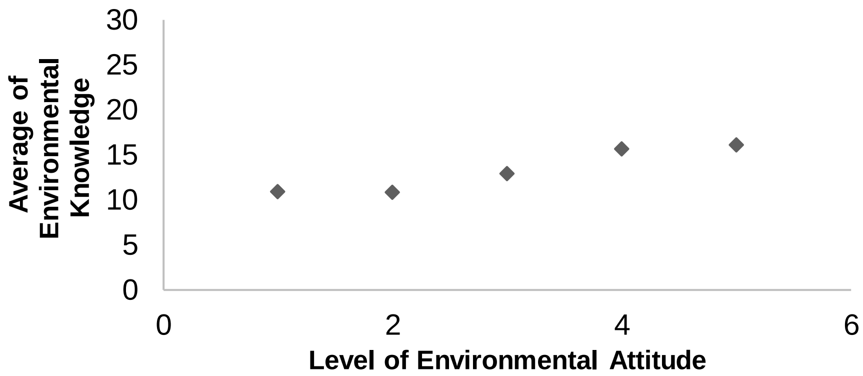
As with any scientific modeling activities, ABM needs to be complete, internally consistent and unambiguous (Nakagawa *et al*, 2013). The ABM research group at Colorado School of Mines has collaborated with mining companies, the US Federal Laboratories and universities and is keenly aware of the importance of model validation as a practice from previous modeling experience. The data from UPV plays a very important role for building a validated model.

2.1 Data showing students' environmental knowledge

ABM is used to understand how information is exchanged among interacting students. More specifically, Universitat Politècnica de València (UPV) has been selected as case study for the reasons mentioned earlier. UPV is a medium-sized university with a student population of about 30,000 distributed throughout three campuses. A survey about environmental issues was conducted at the university, wherein a group of 900 students participated by rating their awareness of the six categories related to their environmental knowledge: (a) the existence of the environmental management system (EMS), (b) the existence and content of the environmental policy, (c) the existence of a waste management system, (d) the existence of the environmental office, (e) the functions of the environmental office, and (f) the existence of the communication system of the environmental office. The members of the group have been randomly selected to preserve the impartiality. All answers are given based on the scale between 1 and 5, with 1 being the minimum level of knowledge and 5 being the highest level of knowledge about the subject. The environmental knowledge of each interviewee has been calculated as the sum of his/her answers over these six categories. In addition, the survey also asks students to rate their perceived level of pro-environmental attitude on campus. Interviewees answer with a scale between 1 and 5 with 1 being the least level of pro-environmental attitude and 5 being the ultimate level of pro-environmental attitude. In short, there are two sets of surveys and the first set of six questions was given to assess the level of environmental knowledge and the second to assess the level of environmental attitude.

The results from the survey taken in 2012 show a mild but direct relationship between the average environmental knowledge and the environmental attitude on campus as can be seen in Figure 1. Although typical attributes of surveys as gender, age, carrier, etc. has been register during the process, no significant variations were detected in the answers when assessing results. Therefore, this additional analysis is not discussed in this first model.

Figure 1. Relationship between the level of the average environmental knowledge and the perceived level of environmental attitude of students.



In the following sections, the characteristics of students and how they interact with each other are described. Since the architecture of ABM is based on the premise that local interactions produce a global phenomenon, special care must be taken in building interaction rules. An over-prescribed local interaction rule can produce biased results, so extreme care has been taken with the selection of the primitive parameters in the model.

2.2 Attributes of students

Each student has a set of attributes. The attributes defined in this model are three folds: Environmental attitude (ENV), Receptivity (REC) and Influence (INF). ENV has been described earlier in this paper. Students carry and exchange information through local interactions. REC defines the amount of information a student can accept from the student that it is interacting with. The INF value of a student defines the amount of environmental awareness that is available to the student he/she is interacting with. With this definition of REC and INF, when two students meet, they exchange certain amount of environmental awareness following the rule described in the Interaction Rules section.

2.3 ENV, REC and INF of UPV

The UPV survey provided a discrete histogram of the level of ENV among the students. The obtained discrete data is mathematically converted into a probability function that is normally distributed with a mean of 3.3 and a standard deviation of $\sigma = 0.9$ as shown in Figure 2.

As more data from the future surveys is accumulated, the discrete nature of the gathered data will improve as an approximation of the true distribution function.

The mean value of ENV has been shifted from 3.3 to 0, keeping the same standard deviation (σ) of 0.9. This modification of the initial data captures the general trend of the actual distribution of the ENV without sacrificing the generality of the initial data for the proposed model. The detailed interpretation of this modification will be given later in this section.

Figure 2. Data of students' perceived level of pro-environmental attitude from the UPV survey taken in 2012.

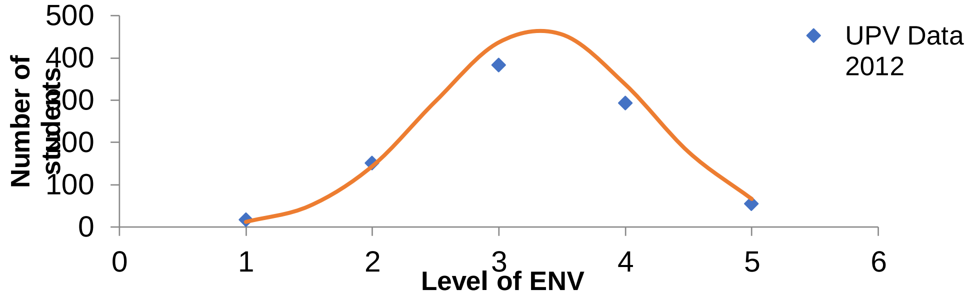
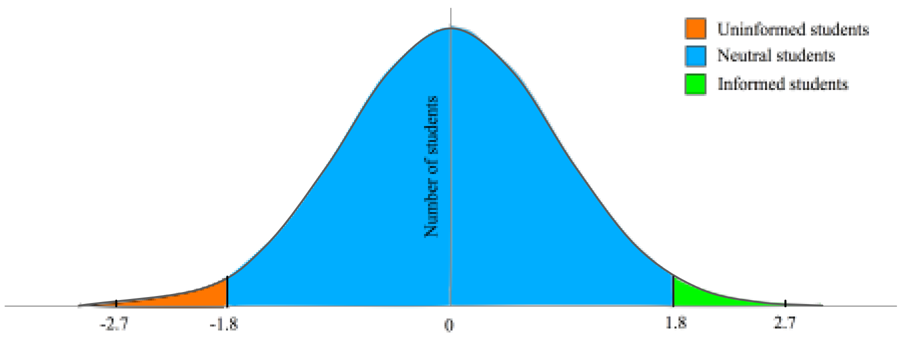


Figure 3. Adjusted distribution of the students' profile over their ENV.



Based on this new distribution, the student population has been separated into three different groups: the *Uninformed*, the *Neutral*, and the *Informed*. Students in the Uninformed group have a strongly negative environmental attitude, those who are in the Neutral have no strong conviction about the environmental attitude, and those who are in the Informed group enthusiastically support the environment with a pro-environmental attitude. It should be noted that for this model the minimum and maximum level of ENV range between -3σ and 3σ (-2.7 to 2.7) respectively, capturing 99.7% of the student population. The Neutral students are distributed between -2σ and 2σ (-1.8 and 1.8) and this establishes 95.5 % of the student population to be in that group. The student population between -3σ and -2σ (-2.7 and -1.8) are in the Uninformed group and 2σ and 3σ (1.8 and 2.7) are in the Informed group.

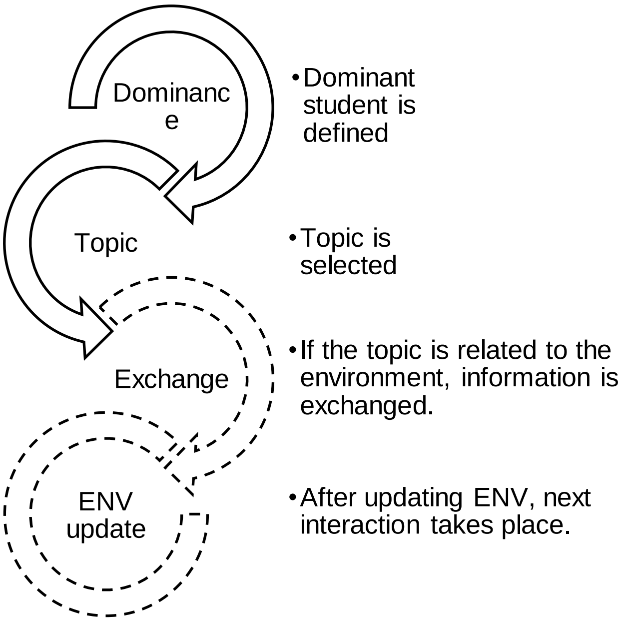
2.4 Interaction between students

Students meet with other students on campus, but for simplicity in modeling, only two students can meet at once and exchange information. There are 450 pairs of students exchanging information at a time as the total number of students who have participated in the survey was 900. This preliminary model takes into account the fact that the difference in each student's personality and the nature of discussion topics at their interaction may influence the way a student's ENV level changes after the interaction. The flow of events that take place in an interaction is shown in Figure 4 and described below.

When two students meet, the proposed model first decides which student is dominant through the statistical process called "Dominance", and then the dominant student chooses a topic according to the process called "Topic". If an environmental topic is selected by the dominant student, then the students exchange information according to the process called "Exchange". If not, no information will be exchanged. Once the environmental information is exchanged, the ENV of each student is updated.

The interaction rule can be explained as follows. First, when the "Dominance" process takes place between two students, each student will randomly be assigned a number between 0 and 1 to define his/her value of influence (INF). The one that has the greater INF value becomes the dominant student that will play a special role in the "Topic" process. If both happen to have the same value of INF, one of them is randomly selected to become the dominant student.

Figure 4. Sequence of events taking place during an interaction.



Once the dominant student is selected, he/she will randomly select a number between 0 and 100. This number identifies a topic assigned to him/her. In order to determine if this topic is an environmental topic or not, Equation 1 will be used.

$$Prob_{dominant} = \frac{|ENV_{dominant}|}{3\sigma} \cdot Prob_{max} \quad (1)$$

In Equation 1, $Prob_{max}$ defines the number of environmental topics out of 100 that are available to any two interacting students. $Prob_{max}$ is arbitrarily set to be 0.1 for now. The number of available topics is arbitrarily set for 100 for this study but this number can also be changed to any desired number without affecting an overall modeling structure. The level of ENV of the dominant student further influences the number of environmental topics that could be available, as shown in the first term on the right-hand side of Equation 1. For example, if $|ENV_{dominant}|$ is 3σ, then all the environmental topics selected by $Prob_{max}$ become available for the interacting students. If $|ENV_{dominant}|$ is 1.5σ, then only 50% of the environmental topics selected become available. $Prob_{dominant}$ evaluates the total number of environmental topics available and a list of sequential numbers is composed based on the total number of environmental topics. For example, since $Prob_{max}$ is set for 0.1, then there will be 10 topics that are environmental in nature and a sequential list of the numbers between 0 and 10 will be developed. Finally, the number that was initially selected by the dominant student is compared against those in the list, and if it is smaller than the largest number of the list, then an environmental topic is selected. This may seem like a very elaborate process just to select environmental topics but in our future modeling, we plan to include topics that are not directly related to the environment but can have strong influence on environmental issues.

Once an environmental topic is selected, then the interacting students influence each other's level of ENV over a selected environmental topic. The way the level of ENV is influenced among students depends on the nature of local interactions that are defined by their receptivity (REC) and influence (INF) levels. The degree of ENV that a student *i* earns or loses, (∆env), depends on his/her level of REC. At the same time, the amount of ENV that the other student *j* makes available for student *i* is defined in the second term on the right-hand side of Eq. 2.

$$\Delta env_i = \left(\frac{3}{5}\sigma\right)\frac{INF_j \cdot ENV_j}{3\sigma} \cdot REC_i \quad (2)$$

It should be noted that (3/5) σ is assumed to be the maximum amount of ENV that a student can earn or lose in an interaction. This value was defined based on the consideration that a student with the lowest ENV needs at least ten effective interactions to completely change his/her attitude in a pro-environmental way. (3/5) σ is the 10% of the total range on ENV. Finally, once the ∆env for each student is calculated, their ENV values can be updated for the next interaction as in Eq. 3.

$$ENV_{i_{t+\Delta t}} = ENV_{i_t} + \Delta env_i \quad (3)$$

3 Results and discussion

A certain percentage of the ENV is exchanged according to the interaction rules defined in the previous section to give the updated ENV of each student. In order to see the internal consistency of the ABM developed here, our simulation model is first subjected to three cases. Once the internal consistency is confirmed, the analysis on the sensitivity of the values for the REC and the initial ENV on the development of the final mean values of ENV are presented.

The following three cases are identified: (Case A) this is the case where a student meets with the same student each time they have an interaction; (Case B) this is the case where the mean REC value of all students in the model is 0, i.e., no student exchanges information; and (Case C) this is the case where students with a positive mean value of ENV accept all of the ENV available and the students with a negative mean ENV value reject all of the ENV available for a given interaction.

3.1 Observation for Case A

Each simulation to test the model's internal consistency was run so that two students interact 1000 times. Three possible cases were identified, and they are: (Case A1) both students have positive ENV values at the time of their interaction, (Case A2) both students have negative ENV values at the time of their interaction, and (Case A3) students have the same magnitude of ENV but with the opposite signs at the time of their interaction. The results of Case A1 and Case A2 are shown in Figures 5.1 and 5.2, respectively. It is expected that the final values of ENV will reach the maximum value for Case A1 and the minimum value for Case A2 at the end of 1000 interactions. This is expected to be true for any fixed values of REC of a student. As seen in Figures. 5.1 and 5.2 below, predictions were confirmed and thus this part of internal consistency is validated. It was also expected that the greater the REC value became, a smaller number of interactions would have been required to reach the maximum or minimum value. This was indeed what was observed although the result is not included here.

In the third case (Case A3), it was expected the final values of ENV to be positive if the REC of the student with a negative ENV is higher than that of the student with a positive ENV.

In the third case (Case A3), Student A has an ENV value of 1 and REC of 0.5, and Student B has an ENV of -1 and REC of 1. The final ENV value is determined by Student A who has a lower REC than that of Student B. For this reason, Student B changes the value of his/her ENV faster than Student A.

Figure 5.1. Case A1 with the positive ENV values.

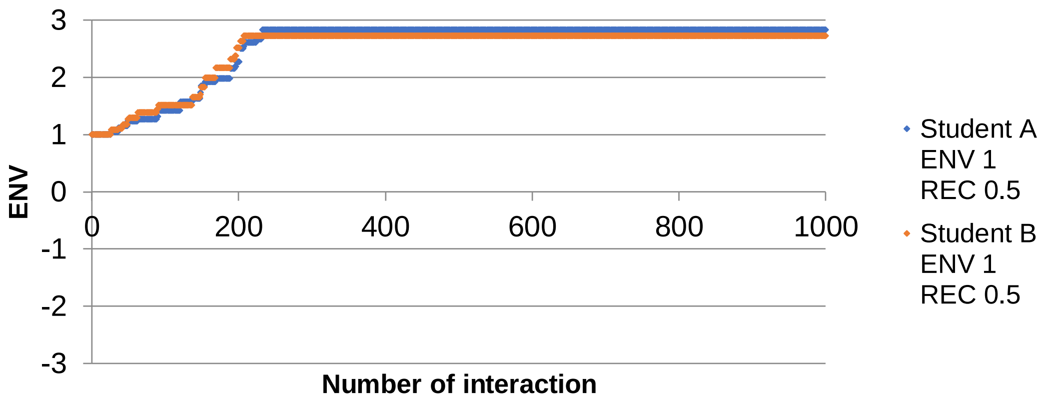
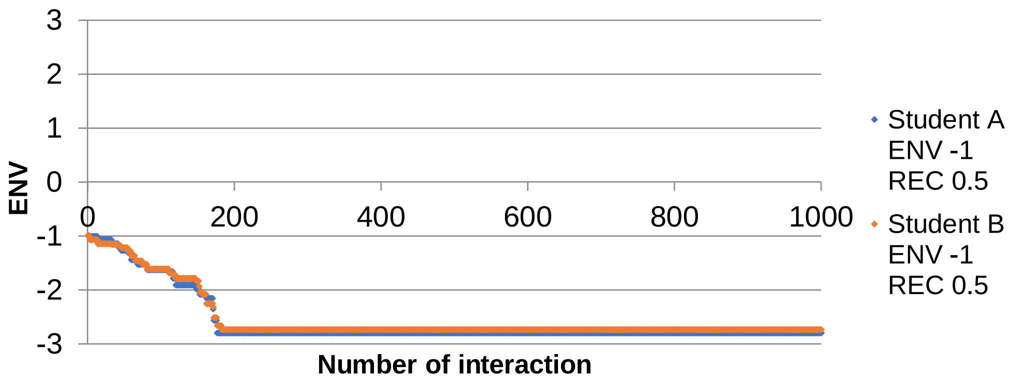
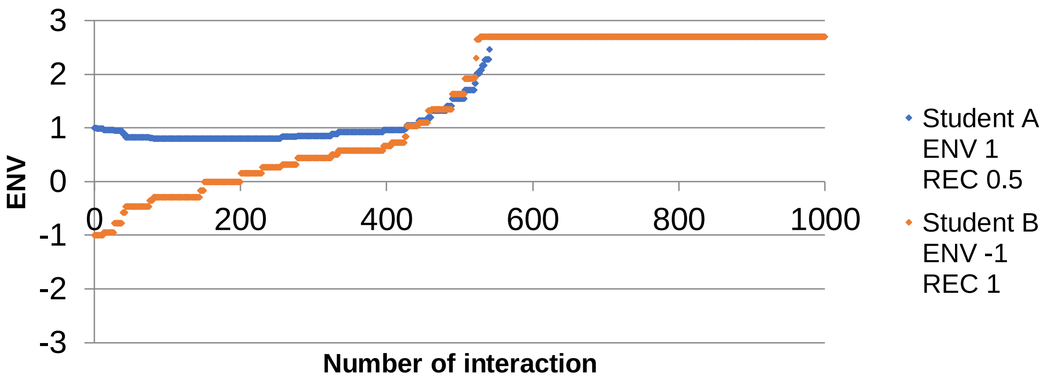


Figure 5.2. Case A2 with the negative ENV values.



Although both students influence attitude in the opposite direction, once the ENV value of Student B becomes positive, as the value of Student A, there is no going back, and the ENV value of both students reach the maximum value of ENV possible as shown in Figure 6.

Figure 6. Result for Case A3 where the REC value of Student B is higher than that of Student A.



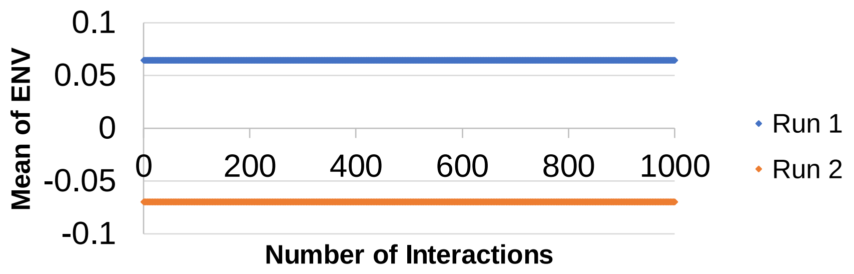
In real life, these results seem to infer that even if two students have completely opposite attitudes towards ENV, if a student with Uninformed attitude is more receptive to accept information, then it is likely that both of the interacting students become Informed supporters.

3.2 Observation for Case B

For this case, the mean value of REC for all students has been set to be 0, meaning that no student will accept information that is given. It was expected that the resulting mean value of ENV remains unchanged during the simulation. Figure 7 shows the results of two simulations with different initial ENV values. Simulation 1 starts with a randomly selected positive value of the mean of ENV of 0.065, and simulation 2 with a randomly selected negative value of the mean of ENV of -0.069. In both simulations, the initial value of the mean value of ENV remains unchanged as expected. These two examples are just to confirm that when there is no acceptance of information from the interacting student, there is no change in the ENV. Different selections of the initial ENV values do not influence the outcomes.

These validation simulations simply imply that it is important for students to be receptive rather than passive towards receiving information regardless of their attitude toward environmental concerns. If students are not receptive, it is, in general, difficult for any information to be transmitted among them.

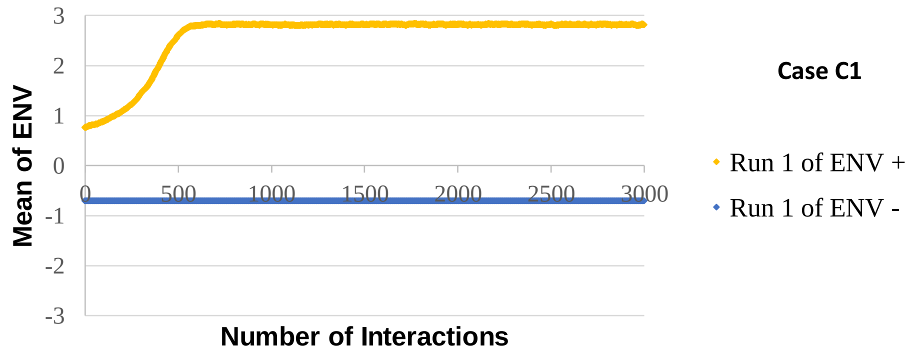
Figure 7. Two simulation runs where the REC value of all students is 0.

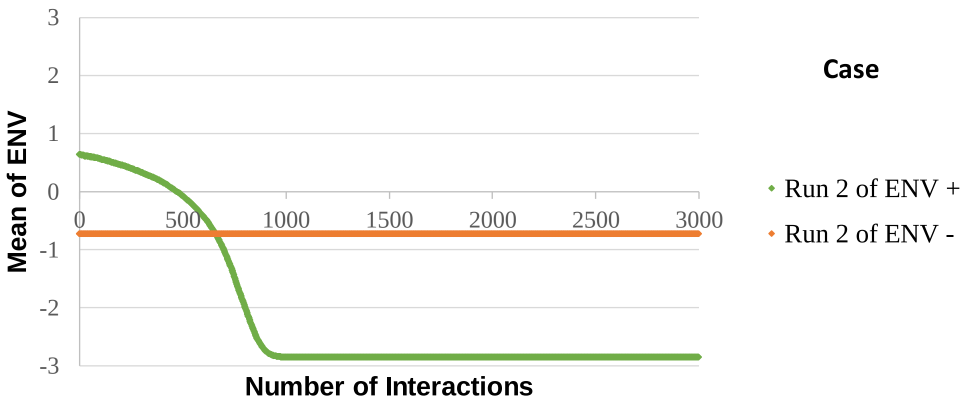


3.3 Observation for *Case C*

For this validation case, the REC value has been fixed to be 1 for all students with a positive ENV value, so that they accept Δenv at each interaction. The REC value has also been fixed to 0 for all students with a negative ENV value, so they lose Δenv at each interaction.

Figure 8. Results for Case C1 and Case C2. The former illustrates the case where the students with the initial positive ENV value interact more with those with positive ENV values. The latter illustrates the case where the students with the initial positive ENV value interact more with those with negative ENV values.





There were two cases, Case C1 and Case C2, observed and shown in Figure 8. For Case C1, it was expected that the mean ENV value of students with an initial positive ENV value reaches the maximum ENV value of 2.9 since these students interact more with other students with positive ENV values than with those with negative ENV values. If the opposite happens, as seen in Case C2 where students with an initial positive ENV value interact more with those with negative ENV values, the mean ENV value of students with a positive value reaches the minimum ENV value of -2.9. In any case, the initial mean ENV value of students with a negative ENV remains unchanged.

Through these validation cases, it has been shown the sensitivity of the REC values on the final outcomes of the ENV values where two students meet at a time of interaction.

3.4 Sensitivity analysis

After having confirmed the internal consistency of the model, it has been performed a series of sensitivity analyses of REC and ENV values in order to understand their influence over the resulting mean ENV values. What follows is a discussion of the results of the sensitivity analysis. First, baseline values have been assigned to the parameters as shown in Table 1. As recalled from the earlier section, the mean value of the ENV distribution and its standard deviation have been defined based on the analysis of students' profiles obtained by UPV. The mean value of the REC has been assumed to be 0.5 assuring that statistically half of the students are considered receptive. The standard deviation of REC and the maximum probability of having a conversation on environmental issues have been assumed as shown in the table.

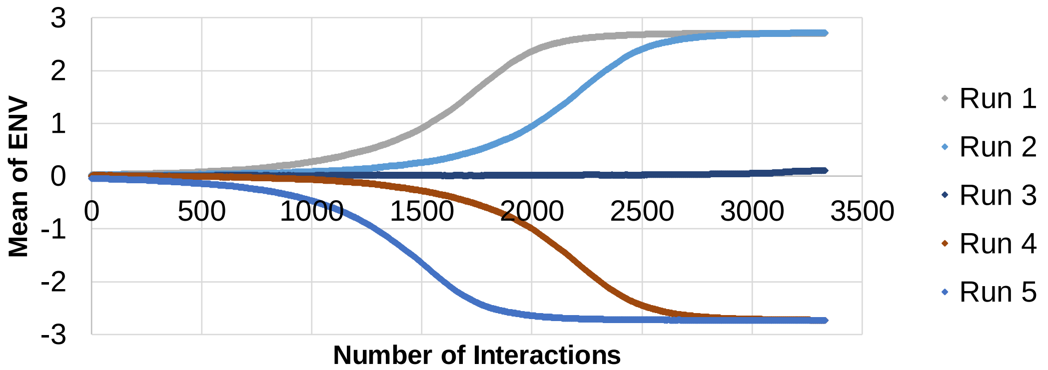
Table 1. Baseline parameters

Parameters	Value
Mean of the initial ENV distribution	0
Standard deviation of the initial ENV distribution	0.9
Mean of the REC	0.5
Standard deviation of REC	0.2
Maximum probability of having a conversation with environmental connotations ($Prob_{max}$)	10%

3.5 Analyses on the sensitivity of the baseline values

In Figure 9 the results for five different simulation runs using the parameters described in Table 1 are shown. Having the mean value of the ENV distribution of 0 implies that each simulation run starts with the same number of Uninformed and Informed students. Results for runs 1 and 2 show that both runs reached the maximum mean ENV value of 2.9 but at different rates. Run 3 shows the result where the mean ENV value hardly changed. Runs 4 and 5 reach the minimum mean ENV value of -2.9 but at different rates, similar to the first two runs. These five simulation runs used exactly the same parameter values as indicated in the table. So, results shown in Figure 9 suggest that with a specific combination of interactions, it is possible for all students to reach the maximum possible value of ENV. Our statistics showed that under the conditions defined by the parameters given in Table 1, the probability of achieving a global pro-environmental attitude was 50%. In summary, with the given initial conditions shown in the table, there is an equal likelihood where the entire student population becomes very well informed or not informed at all of the environmental issues.

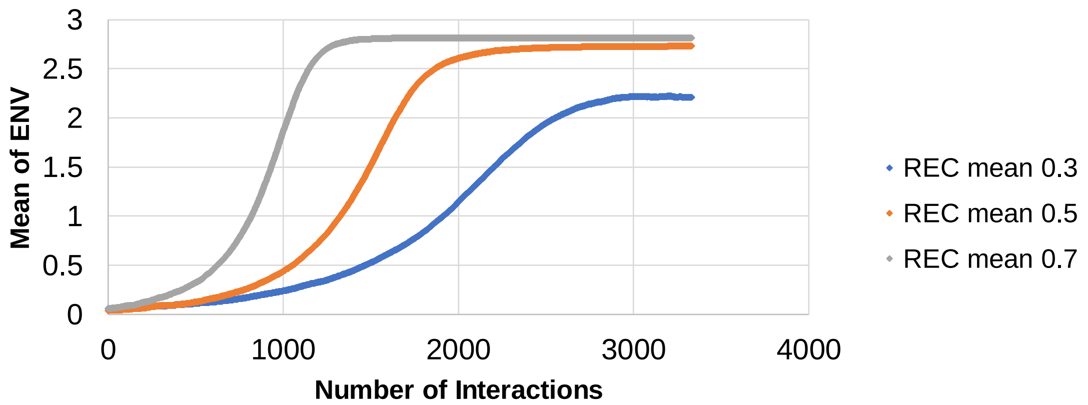
Figure 9. Results of five simulation runs to illustrate the sensitivity of the baseline values.



3.6 Sensitivity of receptivity value on students' environmental attitude

The results on the evolution of the mean ENV values when the REC is varied to 0.3, 0.5 and 0.7 are presented in this section. The mean REC value of 0.5 is considered as the baseline. All the other parameters remain unchanged from the parameters defined in Table 1.

Figure 10. Sensitivity of receptivity on the final mean value of students' environmental attitude with varying REC values.

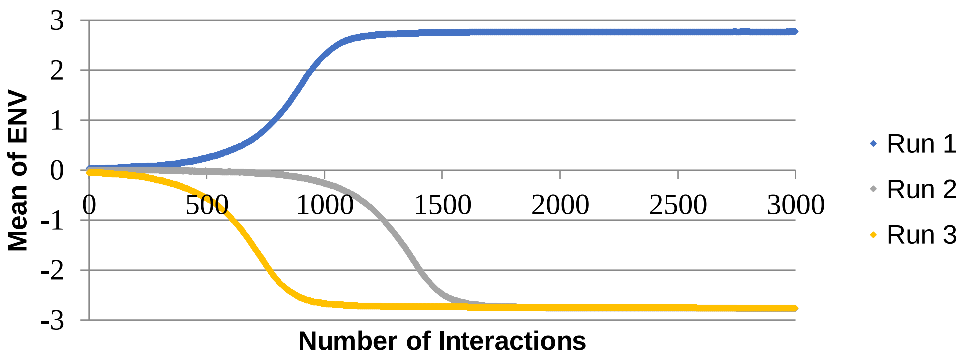


The evolution of the mean ENV value when the mean REC value is 0.7 shows a similar trend to the baseline case with the mean REC value of 0.5 but achieves the maximum ENV value faster. The evolution of the value of the mean of the ENV when the mean of REC is 0.3 does not achieve the maximum value of ENV. It has been expected this behavior because with a distribution where the mean of REC is 0.3 there is a significant probability of having students with REC 0, and all students that start the simulation with a REC of 0 with no receptivity would not change their ENV at all, shifting the maximum of the mean below the global maximum.

3.7 Sensitivity of the initial distribution of ENV

The influence of the initial mean value of ENV in the resulting mean ENV values has been explored; results are shown in Figure 11. In the first simulation run the initial mean value of the ENV has been set very slightly negative, say -0.01. With this initial condition, it was observed that the overall trend of the students' behavior was very similar to that presented using the baseline values; however, the following difference was observed. When the initial EVM value is negative (as small deviation as it was used here, i.e., -0.01), there were two possible outcomes: one wherein the mean reaches the maximum, and the other where it reaches the minimum. Furthermore, it is of interest to note that only 33% of the time reaches the maximum. The low probability of this positive outcome is expected since the runs start out with a bias toward a lower mean. Then the probability of starting a simulation run with a large number of Uninformed students is higher than the probability of starting a simulation run with a large number of Informed students. When the initial mean of ENV was further decreased to -0.06, only 2% of the runs achieved the maximum ENV value. The same argument can be made to explain this lower percentage of achieving the maximum mean value of ENV. What should be noted is that the decrease of the initial value of ENV from -0.01 to -0.06 resulted in the significant decrease in probability of achieving the maximum ENV value from 33% to 2%. Finally, it should also be noted that when the initial value of the mean of the ENV was further decreased to values lower than -0.06, no run achieved the maximum ENV value.

Figure 11. Influence of the mean initial ENV values on the final outcomes.



4 Concluding Remarks

An ABM was proposed to gain insight in understanding the decision-making behavior of students on environmental issues. The statistical profile of the distribution of environmental attitude of students was obtained using the survey data from UPV. The student agents that take part in the model were exhaustively defined, their attributes, the events that they participate in and the interactional rules that drive each interaction between students. The internal consistency of the model was tested based on three extreme cases. The proposed model produced the expected results. Finally, the sensitivity of the two main attributes of students was tested: the receptivity (REC) and the initial level of environmental attitude (ENV). We observed that REC has an influence over the amount of interactions needed to achieve a given outcome. The most significant finding in this preliminary model was the severe influence of the initial level of ENV on the outcome of the final level of students' environmental attitude. A very slight shift of the initial mean value of ENV (from 0 to a small negative value of -0.06) predicted that it is only possible to achieve a campus of Uninformed students. For a better understanding of this trend, a more refined model and exhaustive parameter studies are required.

ABM has proven to be a useful tool in assessing the attitude of students and can give further insight into the complexity of the factors that relate to a successful design of an EMS. In particular, a more advanced interaction model together with more data will help us gain more insight and continuously improve the EMS of UPV.

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