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LEARNING ROUTES METHOD: how to build stronger connections between learners and their learning goals

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Abstract
Research efforts show that several styles and approaches to learning exist: each person learns in his/her own way and learning performances may significantly increase or decrease according to the attention given to this issue. Each person has particular cognitive and emotional characteristics. And it is easy to agree upon the fact that these are strongly tied together, both in space and time. In this scenario, an issue arises very frequently: how can I, as a parent or teacher, educator etc, address this problem while considering all the constraints I encounter? Limits might be determined by: the economic budget, the time and space allowed for working with students, more or less ability of the educator to establish a fruitful communication with the student, and vice-versa. This article addresses a practical and easy-to-use way to take appropriately into account the initial intellectual condition of a person, whenever a teacher, educator or parent has to facilitate learning of the person in a certain direction.

Introduction

After the pre-school age, a person must usually enter a long period of directed, institutional curriculum of learning, which can ~~also~~ span 12 years or even more. A child gets into the school stage with a large range of ideas, attitudes, radical ways of approaching the world, activities, peers, a family and general background environment. This background heavily affects the way he/she thinks and learns. In many situations, this intellectual heritage is almost un-modifiable (Gardner, 1993). Sadly, the meeting between this personal background and the rigor of the curriculum creates situations where the student can be classified as lazy or affected by an attention disorder. In extreme situation, he might even be unable to attend school anymore (Levine, 2003). Many solutions are out there to get rid of this problem (Levine, 2006), even if most of them remain today unexploited.

Each country (or even a group of countries together) decides what must be taught (and hopefully learned) or may decide to provide a less strict range of learning goals. In this case, school educational professionals can decide upon topics interesting to learners (National Council of Teachers of Mathematics [NCTM], 2000; European Parliament [EU], 2006). In a sense, the situation is almost everywhere the same: a teacher in front of a number of young students. The former says something must be learned, the latter agree partially, they do not frequently agree at all and they are very rarely enthusiastic about the goal proposed.

This article does not address the topic of *what* should be taught inside educational institutions, but it proposes a way of *how* a young mind may be invited to get in touch with curriculum topics chosen by the school, the teacher or whoever is in charge. The proposed method addresses mainly situations where learning may be slow and difficult. One of these cases is given by mathematics curriculum. Hence the examples shown at the end of the paper deal clearly with mathematics.

As a side note, there is a huge amount of scientific evidence that learning evolves better when the student is actively interested and involved in the process. The reader is referred to the famous works in Bruner (1960, 1966) and Montessori (1986) and bibliography therein. Anyway, arranging curricula to meet students' needs is not always possible. That's the point where this paper comes onto the stage.

The rest of this work is organized as follows: Section 2 explains the method proposed, its main steps and implementation. Section 3 shows a few possible examples of application to students. Section 4 draws conclusions and proposes possible future research efforts.

2 The Method

A general learning situation can be summarized in this way: a student is close to face a new topic (where the topic may be theoretical in nature, practical, or an ability, a mind habit or else). Of course, this topic is not already inside the mind of the student, or it can be there in a somewhat larger or smaller extent and depths. Anyway, an improvement is advisable, for a number or reasons, depending on the specific situation.

Let's place some starting questions to tackle this issue:

(a) how *far* is the student mind from the topic? And how can we better describe this "far"?

(b) as above stated, if we suppose the topic must be taught, how can an educator build an effective connection between the topic and the student? And, very importantly, how can we build a *practically usable* connection, not only a theoretical one? By "practically usable" we mean a learning path which is viable for the student as well as the educator. Education at its core should be regarded as meaningful especially by the student.

2.1 Step 1: The Internal Home of a Learner

A student always starts every learning attempt moving from his/her own internal home: as addressed in a variety of research studies (Gardner, 1993; Levine, 2002) and bibliography therein, what we call "internal home" is the entire set of mind habits, memories, social and cultural heritage or traditions, personal theories about the world, other people in the world and family, things and fundamental philosophical issues a person always carries inside, whatever he/she does. Moreover, not only the starting condition of a student differs that way but also the learning approach he/she has to the new knowledge to be gained might be very different. This is famously summarized in the groundbreaking work of Gardner (1981) and more recently in his work of 2006. So, how can we represent this internal universe of a young student in a practical way? Usually, teachers have little time to pay attention to this fundamental problem, even when they are really aware of its importance.

Our first proposal here is that the teacher (or the educational staff as a whole) should try to represent the internal intellectual environment of the student using concept maps [Novak, 2010, and bibliography therein]. Concept maps are a graph-like tool which has very good characteristics to allow both a deep understanding of the subject studied (be it a person, an idea or whatever else) and a gentle learning curve to begin with.[1]

Briefly, a concept map has two key features (Novak, 2006): a central concept to be analyzed and a focus question which should drive the attention both of the concept map builder and the concept map reader.

So, how to construct the concept map of the student internal home?

A widely used tool in educational settings is useful for this goal. CmapTools[2] collects many of the features needed to depict the internal home of a learner in a easy way to be implemented. Here we propose two ways this can be accomplished, but of course many others may arise in the future:

(a) the teacher explicitly asks each student to realize a concept map which represents him/herself: this is a key step and can also arrive after a short initial training of

1 At the moment, other graph-like tools seem appropriate for the goal but they have not been used yet by the author.

2 Available at http://cmap.ihmc.us

students to get acquainted with the tool (very easy to use, honestly). The student should be invited to place him/herself as the central concept of the map. The map can show the following as focus question:

• "what would you like to spend time for – say weekly – if you could decide your weekly planning entirely on your own?" (this way of placing questions reflects the assumption well known in pedagogy – and in everyday life – that humans learn better topics they are more interested in)

• "try to describe yourself showing attitudes, qualities, family, friends, hobbies and so on; try to describe your projects about your desired future job, which kind of people you would like to be surrounded by or work with or play with or live with etc." Of course, these questions may heavily vary with respect to the age and other personal conditions of the students.[3] A similar approach to the one here is depicted in Barringer (2010) where the authors suggest the following questions: 1) if you were to design your desired day, what would you be doing? 2) what parts of school are easiest for you and why? 3) what are your affinities – those things you love to do or learn about?

(b) the teacher devotes a certain amount of time to build concept maps of the students' internal homes. We think this way is slower and moreover, has a fundamental lack: it describes the students' internal world the way the *teacher* sees it and not the way the *students* do. This is very prone to misunderstandings and might lead to failures. We understand, however, that time constraints in today educational settings are strict and so this second way can be more viable than the former.

After a while, the internal home of the student is described by a concept map. Taking advantage of the graph-like nature of concept maps, we suggest to represent them via the usual graph notation: MH ={V, E} where MH stands for the Mind's Home of the student, V is the set of all the concepts the students placed in the map, and E is the set of all the links the student drew to connect concepts one another. As far as this notation regards, CmapTools offers an appropriate range of built-in functions which allow to group together and list concepts and linking phrases.

Before going any further, the teacher has to sketch a concept map of the topic he/she wants to teach, as large and detailed as possible. This will be addressed as Topic Concept Map (TCM hereafter).

2.2 Step 2: The Route to the Topic, or the Learning Route

After the first step, the staff has the student's mind concept map. In a sense, the teacher has a deeper "knowledge" of the student and this knowledge is easily and conceptually schematized.

Now what? Let's address a frequent and also to the least desirable situation: the topic to be taught is not *inside* the MH graph of the learner. Otherwise stated, in a less

3 The background of these questions goes back to the interest concept in pedagogical research, where it is clearly stated one of the main forces driving an effective learning effort is placed in his/her interest for the goal proposed. A lot of bibliography exists nowadays, clarifying this part of the problem.

formal fashion, the learner does not ”see” it in his/her practical and theoretical world of interests. Now, irrespective to the hardness of the situation, the concept to be taught is, in the end, a ”concept” on its own. So let’s place it in the MH graph as an isolated node, i.e. it has no link with anyone of the concepts sketched by the student. The second and key step of the method must now be undertaken.

We recall a somehow strict similarity to the backward problem solving process described in Polya (1981): you have a mathematical problem carrying some data and you should get to a solution, which is not directly linked to those data (where directly means with just one logical step). Otherwise stated, you have to build a multi-step connection between the desired result and the actual data you have. Our analogy with the educational problem comes clearer now: the student MH cannot actually be one-step connected with the topic but it might be with a multi-step process. How can these subsequent steps be built? In order to solve this issue we define here the second key concept of our method.

Taking another similarity with a well-known concept in psychology, the “Zone of Proximal Development” by L. Vygotskij (1986) we use here what we call the Node of Proximal Learning (NPL, hereafter). Taking whichever of the nodes (= concepts) written in the MH, the student may be now asked to list topics which he/she is interested in learning, connected to those concepts inserted by him/herself.

Of course, new concepts may appropriately be proposed by the teacher–to students, to check their reactions. This will eventually lead to a set H made by lists of ”desired” topics. The teacher has now to choose the most appropriate topics from those lists, add them to the MH map and see if any of those topics belong to the topic to be taught (or, stated in set like language, if the intersection between the TCM and the MH maps is now not zero).

Two situations may arise:

(a) the intersection is not zero, hence the teacher and the student have built together a meaningful multistep connection between MH and TCM. The educational process begins with the very first step where the student and the teacher now agree upon

(b) the intersection is still zero, hence two steps have to be undertaken: the teacher tries to reformulate the TCM taking seriously into account the {MH + H} set he/she now has. On the other hand, the student tries to do the same with his/her MH + H concept map. After that, the teacher searches again with possible intersections between $\{MH + H\}_2$ and TCM_2

(c) the process goes back to (a) again, until a non-zero intersection arises. After a non-zero intersection is found between $\{MH+H\}_i$ and TCM_i at the i−th step of the process, a multistep connection between the original MH and TCM is done. We would like to stress here that this connection is now meaningful, simply by construction, since it has been built *both* by the teacher and the student, who has enlarged its MH step-by-step until getting in touch with the borders of the TCM, reshaped by the teacher. The topic to be taught should make now sense to him/her, since it belongs to its enlarged {MH+H}.

2.3 Observations

As side notes to the backward learning method, we focus the attention on a number of points:

• the graph approach, implemented via concept maps, give almost immediately a quantitative analysis of the conceptual distance between the usual MH of the student and the TCM studied. Otherwise stated, a teacher may also measure that a TCM is simply one-step away from the {MH+H} and so the process of building a meaningful connection between the two maps is really easy. On the other hand, if the intersection between $\{MH+H\}_i$ and TCM_i is still zero after a long run of iterations in the above process, the connection will be very likely weak and effective learning more and more difficult

• the curriculum may be reshaped, year after year or semester after semester, in order to reduce the multistep distance between {MH+H} and TCM, hence assuring a finer grained and especially more meaningful learning for students, since they will find nearer TCM's to their actual MH's

• MH's have to be periodically reshaped, especially for younger students, since their experience of the world may frequently undergo big changes and this implies careful changes in the teaching approach; of course, the MH's need not to be done again each time a new topic is to be taught

• the method proposed also gives educational staff the opportunity of building a visual portfolio of the students, where the changes of their cognitive attitude toward curriculum topics can be easily tracked

• taking advantage of statistical tools, it is also possible to count how many MH's are 1-step away from the TCM or 2-steps away and so on. The larger the average distance between MH and TCM and the harder the job for the teacher

• it is here noteworthy that the proposed learning method addresses at least three out of four of the main characteristics listed by J. Bruner (1966) about a theory of instruction (ToI hereafter). Of course, the method proposed here is definitely not a theory but it is strictly linked to it. They can be summarized here:

1. a ToI should say which *experiences* are more suitable to generate in a learner an attitude for learning, being it general or particular in nature
2. a ToI should specify the way a part of knowledge is to be *structured* such that it can be readily learned
3. a ToI should address the optimal *progression* to show the topic to be learned

Emphasized words highlight the connection with the method proposed here. Experiences refer to MH, structure refers to TCM and progression refer to the learning path. All these issues are addressed in this work.

3 Implementation

We propose here a summarizing chart where the method can be overviewed in its main steps:

1. assessment of the starting internal condition of the student/learner:

this is accomplished via the generation of a concept map of the MH (Mind Home) of the student where his/her main personal characteristics are schematically depicted; the concept map realization is better up to the student, since it will mirror his/her way of thinking

2. making the TCM (Topic Concept Map) of the topic to be taught by the teacher/educator:

this TCM is better assigned to the teacher/educator, since it mirrors the way he/she sees the topic and so it will eventually highlight important differences between students' and teachers' way of thinking

3. searching of the conceptual route between MH+H and TCM via subsequent nodes linking (called Nodes of Proximal Learning) eventually building a meaningful learning route.

3.1 Examples

We show here a possible situation where this method may be useful. Of course, more examples will come from experimentations on site, like in schools and many other educational places.

Let's assume the topic to be taught is "cartesian 2 dim space and its coordinates", which in turn belongs to the very general topic of cartesian geometry. First of all a student has to build his/her own conceptual map, where he/she places things considered interesting in his/her way of seeing life around.

Here we report two self-concept maps built by students of secondary schools, aged 14. Of course, maps can contain conceptual or logical errors, but the author decided not to correct them because these errors should be taken into account when trying to understand the way a student thinks. White nodes represent the MH of the student, orange nodes represent the TCM and green nodes highlight the learning route between the two maps above.

Of course, two students are not a statistically relevant test set, but the NPL's routes found may be very useful in undertaking the activity with those students. A whole range of educational experiments should be started in order to gain a deeper understanding of this method. Concept maps were made by students on their own.[4]

The MH of the two students is composed of all relevant nodes they put into the map. The distinction of a relevant node from a not relevant one is subtle, and it may depends on a variety of factors: the TCM, the teacher point of view itself, possible prior interviews to the students which may integrate well with the actual map built and add new knowledge about the students, etc. We will strictly follow now the protocol proposed in Section 2, hence the key steps are as follows:

4 Maps have been translated into English, since they were written originally in Italian. No nodes have been hidden or modified, neither during nor after the completion of the map by the student. Only personal names of the students, of their friends, of their relatives and other personal data like the school or the city have been modified and are totally fictitious.

1. initial assessment of the starting internal condition of the student/learner, i.e. the learner's MH

2. realization of the TCM (Topic Concept Map) of the topic to be taught by the teacher/educator

3. searching of the conceptual route between {MH+H} and TCM via subsequent nodes linking (NPL nodes), eventually leading to a meaningful learning route.

Student 1

step 1: initial assessment of the starting internal condition of the learner.

Please, note that different concepts are separated by a slash "/". In this context, we will highlight the possibility of linking the MH with cartesian geometry.

MH = { student 1 / football / building and programming robots / youngest son of his father / brother of john / my school first grade / swimming pool / sports / talking with friends / go out on saturday nights }

step 2: realization of the TCM (Topic Concept Map) of the topic to be taught by the teacher/educator. See the nodes highlighted in orange in figure 1

step 3: searching of the conceptual route between {MH+H} and TCM via subsequent NPL nodes.

The most suitable node to be taken into account is the one called building and programming robots. The teacher may ask the student if he/she may be interested in programming a simple code to drive the robot around a certain zone, following a desired path. In case of acceptance, a new NPL is found and this will lead to a new node called "simulation routes" or "simulated routes on a field", that can be used to determine the following learning route to cartesian geometry:

{"simulated routes on a field" - also called - "trajectories" - described in terms of - "cartesian coordinates" - is used by - "cartesian geometry"}

So, in this setting, we may get a multistep connection between the student and the topic, via realistic intermediate learning goals, highlighted by green in the figure. The green and orange concepts are added after the initial concept map has been built, i.e. they refer to sets like {MH+H}.

Here we report for the sake of completeness the new and final set {MH+H} where concepts belonging to the set H are reported in italics.

{MH + H} = { student 1 / soccer / *cartesian coordinates / cartesian geometry / cartesian plane / circles, ellipsis, parabolas, hyperboles / building and programming robots* / youngest son of his father / brother of John / my school / first grade / lines / *many geometric objects* / swimming / *simulated routes on a field* / sports / talking with friends / *strange curves / trajectories* / go out on saturday nights }

Student 2

Let's now turn our attention to the second student's map.

step 1: initial assessment of the starting internal condition of the student/learner

MH = { student 2/ big nose / friendly / listen to music / basket / clear / brown / chatting / computer / body /enjoy my life / sleeping / facebook / playing / Tom / watching interesting videos / play role / inventions / slim / eating / fashion / not enough time to make things / news / taking rest / playstation / sports / record / normal / always moving / talk about myself / happy / joker / my computer / talking with friends / being stuck / studying / willing / dresses / face }

step 2: realization of the TCM (Topic Concept Map) of the topic to be taught by the teacher/educator. See the nodes highlighted in orange in figure 2.

step 3: searching of the conceptual learning route between {MH + H} and TCM via subsequent NPL nodes. In this case, finding a reliable route made of subsequent NPL's has been somehow harder. But the author is confident it may be useful also in this situation. Here we report the route built:

{field - technological - like - "robotics" - useful also for - building extraterrestrial probes - goal - routes - by - moving autonomously in a new planet - defined by - programmed coordinates with computer languages - uses - cartesian geometry}

For the sake of completeness, we report the new and final set {MH+H} where concepts belonging to the set H are written in italics.

{MH+H} = {big nose / friendly / listen to music / basket / clear / *cartesian geometry* / brown / chatting / computer / *programmed coordinates with computer languages* / body / enjoy my life / sleeping / facebook / playing / Tom / watching interesting videos / play role / invetions / slim / eating / fashion / *moving autonomously in a new planet* / not enough time to make things / news / taking rest / *routes* / playstation / sports / *building extraterrestrial probes* / record / normal / *robotics* / always moving / talk about myself / happy / joker / my computer / talking to friends / being stuck / studying / *technological* / willing / dresses / face }

Again, white nodes belong to the MH of the student, green nodes belong to the learning route built and orange nodes belong to the TCM. A final remark is important for learning routes: they have been built using robotics concepts in both cases. Of course, a huge number of other connections can be made. They depend on the MH's of students and can be constructed by many other tools like math manipulatives, computers, literature, music, science and so on.

4 Conclusions and Future Work

This work shows a practical way to build a meaningful learning route between the inner emotional and intellectual world of a student and a topic to be taught by a teacher. This method tries to be an easy to implement way to link students' interests to fixed curriculum topics. This is especially desirable in many situations where it is neither possible to strictly follow the former nor to rigidly adhere to the latter.

This is a starting idea and a lot of work needs to be done:

• tests with a far larger number of students, in order to gain a better understanding of their learning differences and of their starting MH's

• tests in a variety of settings, like primary and secondary schools. It is advisable to test the method also outside schools, e.g. universities and beyond, especially the corporate sector.

Figure 1: Concept Map of the First Student.

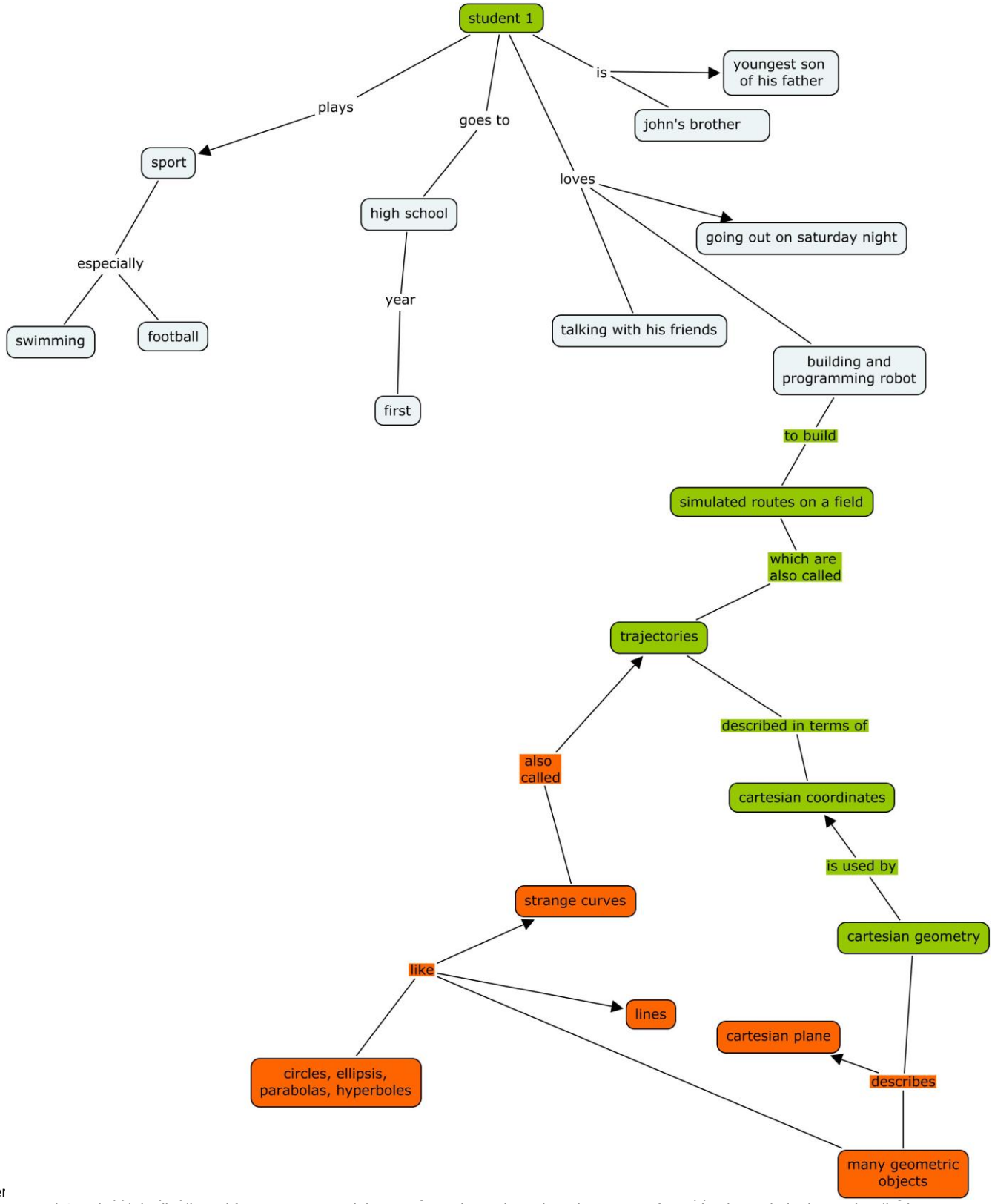
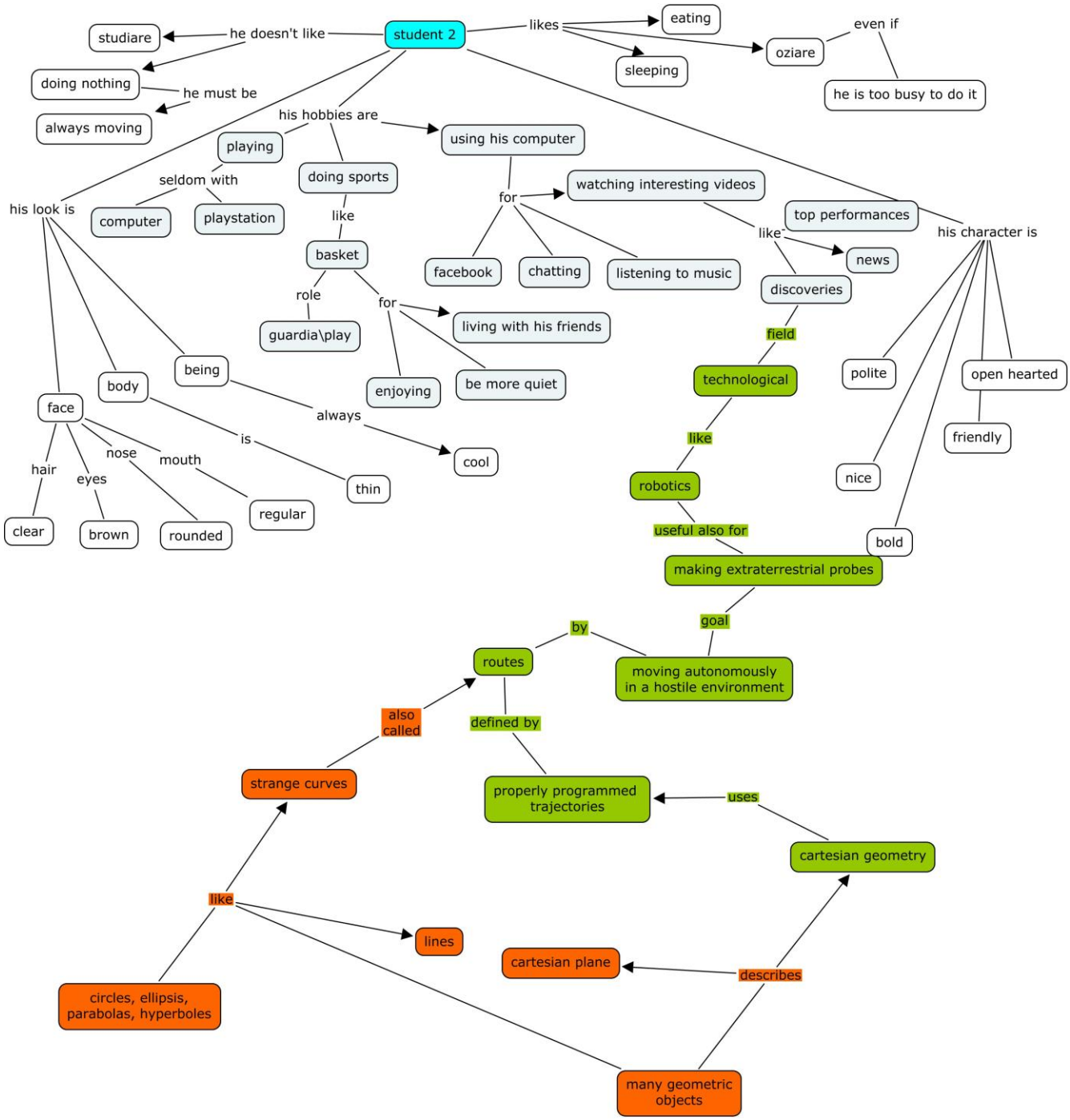


Figure 2: Concept map of the second student.



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