Designing Robotic Artifacts: Rural School-Community Collaboration for Learning

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ABSTRACT

The development of a community is reflected in the efforts designed to improve the economic and social atmosphere, and the quality of life of the community. Nevertheless, community development specialists have focused on economics, ignoring other aspects of development and the interrelation of such. The goals of this proposal are: 1) To study how the design of robotic artifacts and the use of other digital technologies can enhance student learning, while also contributing to improvement in rural community life; 2) To explore how the relationship between learning, technology, and culture can be employed to inform new educational approaches that build a strong school-community relationship through out the use of technology, and thus, close the gap between rural and urban life. In this paper, the different aspects of the research program will be described, as well as some sample projects made by the teachers and children during workshops conducted recently in a rural community in Costa Rica.

Keywords

Rural Education, Curriculum, Development, Constructionism.

INTRODUCTION

The development of the community is reflected in the efforts designed to improve the economic and social atmosphere, and the quality of life of the community (Miller, 1995a). Nevertheless, community development specialists have focused on the economics, ignoring the other aspects of development and the interrelation of such. Researchers and experts on aspects of rural development believe in the potential of links between school and community (Miller, 1995b; Natctigal, et al.; 1989). In fact, some rural schools have managed to demonstrate that when these look for learning opportunities in the characteristics and needs of their community, thus involving their members in the school's work, both the school as well as the community have great possibilities of improvement and development (Harvard Graduate School of Education, 1999a).

What would be the appropriate strategy for an integral development of the community? What will be the appropriate tools in a rapidly changing world? An attempt to contribute in finding some answers to these questions will be proposed on a methodology of work that looks to build strong school-community relationships. This methodology is part of a research program at the MIT Media Lab[1], called RURAL.

THE PROPOSAL

The research methodology that constitutes the foundation of this research program combines the theories of Participatory Development and Constructionism. In one hand, some of the underlying elements of Participatory Development theory will be used to approach the community and create a team that will support and continue the work at the local level. On the other hand, Constructionist methodology of work will be used as means to engage people in building their own knowledge and thus, creating their development.

Participatory Development is a process anchored to local values and knowledge, defined and facilitated through the participation of those whose lives are most directly affected (Piciotto, 1992; World Bank, 1995). It covers and builds upon concepts such as community, religion, sustainability and empowerment. The research program will work on the principle that community-based development is a participatory process most effectively approached in a bottom-up fashion.

Constructionism is both a theory of learning and a strategy for education (Papert, 1980). It builds on the "constructivist" theories of Jean Piaget, asserting that knowledge is not simply transmitted from teacher to student,

[1] More information on this research program (http://media.mit.edu/~calla/rural.html)

but actively constructed by the mind of the learner. Children don't get ideas; they make ideas. Moreover, Constructionism suggests that learners are particularly engaged in making some type of external artifact-be it a robot, a poem, a sand castle, or a computer program-which they can reflect upon and share with others. Therefore it takes an interventionist perspective and concerns itself with the design of learning environments (Harel, 1991; Hooper, 1993; Cavallo, 1999) and construction toolkits that can encourage learners to make epistemological, as well as personal connections (Resnick et al, 1996).

The Curriculum

One of the more important aspects of this proposal is the curriculum, which is called the "evolving curriculum". ”Evolving” by definition refers to the flexible, dynamic, and unsettled nature of this curriculum. The proposed curriculum will keep evolving and remains unfinished as long as the schools and communities decide to participate on the research program and incorporate its methodology of work to their reality. Assuming that the curriculum is finished would mean that the learners have finished learning and that the communities have stopped changing, which is never true. The structure for the curriculum is built on three main pillars: community needs, current curriculum and strategies for development.

In order to assess the needs of the community, it is necessary to observe the characteristics of the community, and each organization within it. Therefore, interviews and observations will be conducted at the school, local hospital, and a number of households in order to gather the initial information. It is also important to include all points of view and opinions about the well being of the community. In order to achieve that, discussions with formal and non-formal community leaders will be included in the assessment. In regard to the current curriculum for both countries, Colombia and Costa Rica, where the pilot experiences are being implemented, there is a National Basic Curriculum. All the schools must satisfy this National Basic Curriculum at a minimum level. They have the freedom to add to this curriculum what they consider relevant and appropriate to their own reality. These minimum requirements are translated into the proposed project ideas or themes, and can be changed when necessary. Finally, some development projects that this research program is looking to promote deal with identity and cultural values, community leaders and participation, communication and access to information, development of new skills—self development and problem solving, search and management of new business, and expertise through alliances with experts.

The curriculum is a set of project ideas organized according to the structure. The project ideas will depend on each of the sites where the research program is being implemented, which means that every curriculum is different in each of the sites, but its project ideas can be shared with members from other schools and communities that participate in the research program. Each of the project ideas or units can be indexed by the different parameters of the curriculum. A person may want to look at a project idea or theme according to the National Curriculum, because of the national requirements, and other one may want to find a project according to the community needs or problems that are addressed under the theme. This will make it easier for people to share and understand project ideas.

Learning Environment

A key element to the success of this proposal is the creation of the appropriate learning environment. Ideally, the environment should allow enough freedom so learners can work on an immersed project-based learning (Bers & Urrea, 2000). Project-based learning means that learners can choose a project within a proposed theme of work. They should be able to choose the ideas they would like to explore, and the resources they would like to include on their experiments, solve the challenges, discuss and present their final project with each others and with other members of the community. Immersing learning refers to the notion that learners immersed themselves in the learning process by having a lot of time devoted to play and to explore their ideas in depth. Learners should be able to try many ideas and have enough time to iterate through different versions of a same idea. An appropriate learning environment should provide the learner with the right elements, so they can be in control of their own learning. In the past, research has considered the child as the main learner within the learning environment, giving less or not enough attention to the teachers (Butler, et. al, 2000). In this research program, the important role that the teachers play on the implementation and development of the program is recognized, so teacher's needs and inclinations as learners will be greatly considered and supported.

Technology

The use of construction toolkits that support children and adults learning process is another important element of the proposal. Technologies that not only allow, but also encourage design-based learning can be important within this research program for many different reasons: people are responsible for their own learning, they can work at their own pace, and have the tools and the elements that allow them to reflect upon the projects and artifacts they create. These characteristics are very important for the goals of this research program since the learners are able to revise and change the projects they build around a particular problem or aspect of their community. The type of construction toolkits that allow people to build all sorts of `artifacts` as well as program them to interact with the world through sensors and motors is the first step even before introducing the elements of the curriculum.

Hardware

The proposed technology for this research program is called LEGO Mindstorms. The retail package comes with an "RCX brick," electronic sensor, and a number of LEGO components, such as motors, gears, axles, wheel, and bricks. The RCX brick is microcomputer embedded in a LEGO brick, and it has been under development for almost 12 years. It has been the result of the collaboration between LEGO and a group at the MIT Media Lab led by Fred Martin (Martin, 1988). The brick can be programmed using a PC to take data from the environment, process information, and power motors and light sources.

Programming environment

The RCX brick comes with a programming graphic environment. There are two version of the programming environment available on the market: RoboLab, which is design for educational purposes and market by LEGO Dacta, and the RCX Code, which comes with the retail package. Both environments have been evaluated, but they are only available on English languages. The rural communities where the pilot sites are being implemented are located in Colombia and Costa Rica, both Spanish Speaking Countries; therefore the use of those environments is not possible.

A third programming environment has been used at the sites. This programming environment is called Yellow Brick Logo or RCX Logo[2]. This software is built on top of MicroWorlds Logo software. The basic Yellow Brick Logo interface is shown in the Figure 1.

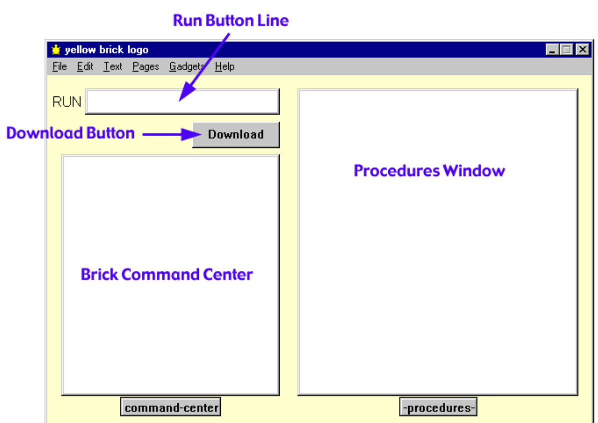

Figure 1. Yellow Brick Logo interface.

The Yellow Brick Logo was originally written in English, but it was easily translated to Spanish. It has a Brick Command Center, where Logo statements can be typed and immediately sent to the RCX brick to be executed; a Procedures Window, where users can write Logo procedures, which can be downloaded to the RCX, using the Download button; and finally, the Run Button Line, which is used together with the green Run button on the RCX to run programs.

[2] The Yellow Brick Logo was developed by a group of researchers from the Epistemology and Learning groups at the MIT Media Lab (http://el.media.mit.edu)

Other Communication tools

Other communication tools will be used as part of the proposal, but they will be introduced during a third phase of implementation. These communication tools will support learning, and facilitate community building and development through creation, access and use of information relevant to the members of the community. The goal is to encourage socialization and facilitate communication among members of a community of teachers that share the same interests and activities, but that are not necessarily in the same physical place.

Implementation

The implementation of the research program is divided in 3 phases (see Table 1).

Phase 1. Preliminary Study and Needs Assessment. This phase is the departure point for the research program. The study of needs will continue throughout the implementation and it will become a means of regulation and feedback-gathering for diverse aspects of the program.

Phase 2. Building Community. The main goal for this phase is to build a strong sense of community through our collaborative work among members of the school and the community. This phase is very important because the technological tools and methodologies of work will be introduced in the learning atmosphere and start to be adapted to the reality of the community. This phase will begin once the needed resources are taken to the rural community and schools.

Phase 3. Moving Beyond Community Boundaries. This phase will be dedicated to provide communication and support tools for teachers. These communication tools will allow teachers to build a community with other participating teachers who share the same interests and activities. They will be able to access projects and ideas, as well as make their own available to others. This phase of the program will begin once the tools and communication infrastructure are in place.

Phase	Goals	Activities
1. Preliminary Study and Needs Assessment	- Find possible sites for implementation - Assess community needs by means of interviews and observations - Find a local group that interested in working with the research program. This group will be dedicated to support and adapt the program to their local community	- Visits to possible sites of work in Colombia and Rich Costa - Selection of schools and communities where the program will be implemented - Interviews and observations at the rural communities - Evaluation of community needs according to the observations and interviews
2. Building Community	- Obtain resources for the implementation of project in the different rural communities - Define the vision of the research program with the people involved - Discuss tools and methodology of work - Evaluate tools (software and hardware) - Reinforce and encourage collaborative work between the school and the community - Evaluate and refine the proposal	- Creation of budget for the program at the different sites - Discussion of the vision of the research program with people involved - Technical meetings with the support group - Collaborative workshops with teachers and/or students - Collaborative workshops with community members - Collaborative elaboration of the evolving curriculum

3. Moving Beyond Community Boundaries	- Create a mechanism of communication for the teachers of the rural areas - Introduce communication tools to the learning environment - Support the teachers when creating and exchanging projects - Evaluate and refine the proposal	- Creation of budget and search of resources - Workshops with communication tools - Support in the construction and preparation of projects for curriculum - Final evaluation, and report of result and recommendations

Table 1. Implementation of Research Program.

EL RODEO, A RURAL COMMUNITY IN COSTA RICA

There are several sites for the RURAL research program in Colombia and Costa Rica. San Marcos de Tarrazu is a town of about 25,000 people in the mountains of Costa Rica, south of San Jose. Even though the research program is being implemented at the small rural school and its community, called El Rodeo, the computers are part of a research project called LINCOS[3]. LINCOS (Little Intelligent Communities) is a modern community center with information and technology platforms and an educational and sustainable development approach for the use of technology. The first effort to work directly with the school and the community started on spring 2001. Several workshops were developed during a week of work.

Working with the teachers

The school principal, four teachers, and few of their own children participated during the first workshop. The workshops started with a presentation and discussion about the vision of the research program. The discussion generated a lot of questions regarding collaboration and future participation on the program. The teachers felt skeptic about their ability to carry on the program, since most of them didn't have any experience working with computers.

The next part of the workshop was dedicated to explore the technology. They spent a lot if time exploring the programming language, building simple structures with Lego, and creating small programs that made those structures move. It was very interesting to see the kind of collaboration that emerged from this experience. Teachers were given challenges that they had to solve. For example, they were asked to build a contraption using a touch sensor and a motor. They also had to program it, so every time the touch sensor was pressed, the motor started to run for 2 seconds. They quickly started to share ideas and programs. They were all able to complete the challenge. Some of them went even further and stated to create their own ideas. By the end of the day some of the teachers said, "I want to come back tomorrow," as if they were planning not to finish the workshop even before it started. All of the teachers came back the next day, and they even brought their children, which made the experience even more fun for them.

The last part of the workshop was dedicated to build projects or `artifacts` using all the elements accessible during the workshop. They were asked to choose any idea that interested them, either within the classroom or in their personal lives. They formed three groups and spent the rest of the time designing and building their projects. Teachers as well as children work collaboratively on the formulation as well as the construction of each of the project, which they presented at the end of the workshop. The projects that they built can be classified in the following categories.

Projects that reflect problems in the community

A smart classroom was built by a kindergarten teacher and her two sons. The teacher wanted to work on a project related to the situation of her classroom. She wanted children to be aware of the need for preservation of limited resources. The teachers said, "I first had the idea of building an intelligent classroom that would indicate when water is running and lights are on, because they are always on in my classroom and I have to keep turning the off all the time. We also wanted to build an intelligent car; and to combine the two projects, we decided to build an intelligent garage." When asked about the way she would like to work with her class using the resources she had been working with during the workshop, the teacher said, "I would like to have a discussion with my groups about

[3] More information about the LINCOS project can be found on their web site (http://www.lincos.net/).

energy and water preservation. First, I would present to the children the project I built, and ask them to come up with their own solutions to save water and energy. In a similar way, I will talk about pedestrian safety and car accidents, which are very common in the community, and present the project to generate ideas."

Another project with the same characteristics was a meteorologist unit. The project was made by two of the teachers and their children. They wanted to use the project to talk to the children about the ozone layer, the irreversible damage done to it, and its future. When presenting the project one of the teachers said, "We were very interested on working with the concept of pollution, the ozone layer and how we have to avoid doing any further damage to it. We build an artifact to measure the heat and the intensity of light. Among those functions, it has a heat sensor. When the heat sensor gets to certain value—we gave it an initial value to compare to—it would set the alarm to go off. The other is a light sensor, when it gets to certain value, it would indicate the radar to start." They also wanted to use the project to generate reactions and solutions from their group of students at school.

Project that cross subjects

This project was a transportation vehicle, created by the rural school's principal, a teacher, and a kid from the neighborhood. The group worked on what they thought was the most appropriate vehicle to get to the community, a "helicopter." The teacher presented the project to the rest of the group. She said, "When elaborating this project, we tried to study means of transportation. The goal was to build a helicopter, which we consider the most appropriate aerial mean of transportation that can get to this area." This group went even deeper when thinking about way in which they could use the project with their groups at the school. They said, "We will use it in social studies, to study different means of transportation. In science subject, we will use it to learn how to reduce pollution, and to study gears and different types of energy. In math, we will use it to learn about geometric figures, sizes, parallel lines and other types of lines. In Spanish, we will use it to reinforce word spelling."

Project to learn about technology

The intelligent car on Figure 2 was a project built by the son of the kindergarten teacher. He came the first day to drop his mom to the workshop and decided to stay. He was very interested in the technology and was willing to do any project in order to build and play with the RCX brick. He wanted to build an intelligent car, and he had problems thinking about ways in which he could incorporate his ideas with the rest of his group, but his mom did a very good job at accommodating all the group ideas and interests. She suggested building an intelligent garage instead of intelligent classroom. It is obvious why she is the kindergarten teacher.

When presenting the project to the rest of the group, he said, "The car has four light sensors that work separately. We spent a lot of time working on the diagram to connect those four sensors. There are only three inputs to the RCX brick, so we had to figure out how to connect the four sensors in order to detect which sensor was near an obstacle." Jimmy was so proud of his creation, but not all the participants could understand the powerful learning experience it was for him.

Figure 2. The Intelligent Car

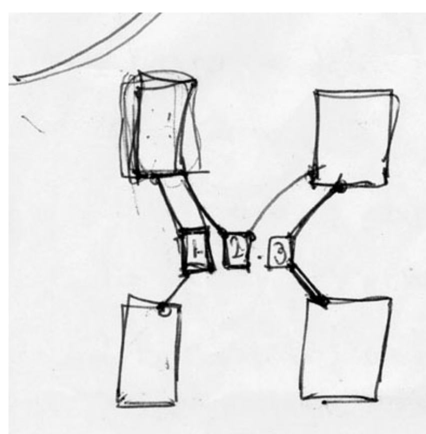

Figure 3. Diagram for the Sensors

As you can see on Figure 3, the number 1, 2, and 3 represent the inputs for sensors that the RCX brick has. The boxes represent the number of sensors needed for the car. The first upper left sensor is connected to the inputs 1 and 2, the lower left sensor is just connected to inputs 1, and so on. When the RCX detects a change on input 1, it checks for a change in input 2. If the change is only detected in input 1, it knows that the obstacle is around the rear left side and it takes action according to that.

He finished his presentation by saying, "When the car starts the initial value of sensors gets store. As the car moves, it changes the direction according to the inputs it receives from the four sensors." As he continued telling the story of his project, he said, "My idea was to make the car turn, but we did not have time to build a rotation system for the front wheels." In fact, Jimmy did not have enough time to finish the car, as he initially wanted. He spent most of the workshop building what seemed a simple car.

Working with the children

There were 25 children from the 3rd and 4th grade for the first day of the children's workshop. We started with a game, and a discussion about their community, which ended with them drawing a picture of their community to use at the end of the workshop. When children were asked about the things they wanted to change in their community, they talked not only about their community, but also about their families and the relationship between their parents. Statements like, "We don't have money to change things" or "We are poor so we can't afford to change anything" reflected their feelings about situation that affected them in their everyday lives. Conversations with children can be a good way to assess community needs and get a sense of how people see themselves. These conversations can also get translated into ideas for themes to work with the children within the proposed methodology.

Eight teams of children were created to work with the Legos. The children were asked to figure out how to build a vehicle by incorporating the motor, wheels, and sensors. They continue to work with the programming aspect of the technology. Only a few basic commands for motors and sensors were introduce to the children. The commands were written on big pieces of paper. The children had to use the vehicle in each of the commands in order to understand how the commands worked and how they had to use them. They often went back and rebuilt their vehicles to make them stronger or to incorporate other motors and sensors. For the rest of the workshop the group divided in two subgroups according to their regular class schedules. The children from the 3rd grade worked during the morning, and the children from the 4th grade worked in the afternoon. The children decided the project they wanted to work on based on our discussions. Some children worked on projects related to the community, others on simple artifacts present in their everyday life. All of the children spent a lot of time decorating their projects. They wanted to use every available material we had on hand.

Projects that reflect community needs

The group of children from the 3rd grade decided to work on "their community." They chose their projects after discussing things they liked about their community, and things they wanted to change. Some of the children decided to build sturdy vehicles that could go up on a very steep incline (Figure 4). Others decided to work on recreation projects, building a Ferris wheel (Figure 5) and pool. Almost all children spent time creating a landscape with art materials and objects they had picked from the garden.

Both kinds of projects reflected the needs and worries that children have in their lives. On one hand, the building of vehicles reflected the transportation difficulties they have. The road to the community is a dirty road in poor condition. If you don't have a very sturdy car, you have to pay for a jeep-cab ride or you have to walk. On the other hand, the fact that the children talked and built projects related to recreation reflected their need for better resources, which are important for the well being of the children and the community in general.

Figure 4. The Vehicles **Figure 5**. The Ferris Wheel Project

Projects that reflect community wealth

The children from the 4th grade were more intrigued by the building blocks they had available. We started a conversation about things that were familiar. When asked about things they knew that require motors, other than cars, the children started to name all the appliances they had at home. They created groups of two to three and worked on a project related to these appliances. They built a refrigerator that had a light sensor to detect when the door was open in order to turn on a light, and a temperature sensor to control the motor inside. They also built several washing machines with a motor inside; some of them incorporated touch sensors to detect when the door was open in order to stop the motor. Children, girls in particular, spent considerable time doing very detailed work for their projects (Figure 6 & 7).

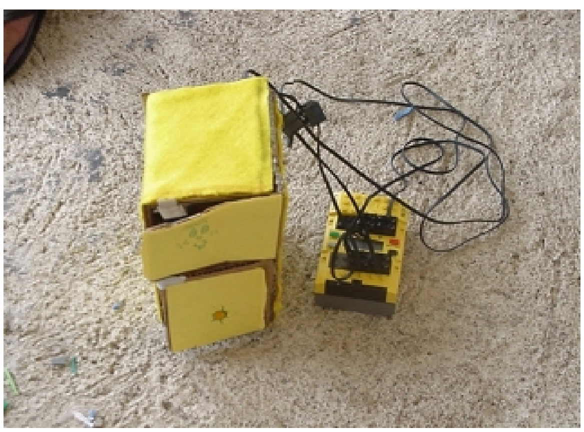

Figure 6. The Refrigerator. **Figure 7.** The Washer Machine.

CONCLUSIONS

Issues regarding development are very controversial: Who should be involved? How much intervention from people outside the community is appropriate? What issues should be addressed first? These are questions people coming from different disciplines have tried to solve in different ways: migration to the urban areas with greater possibilities of work, rural activities outside the agricultural sector, projects in the recovery and conservation of the natural resources, and social safety nets for the population without an agricultural option, among others (Echeverria, 1998; Harrison, 2000) The research program presented in this paper proposes an attempt to solve these questions using an approach that involves all members of the community. The collaboration that results from the work done by the member of the school and the community is expected to make a big impact on the ways in which people in the community see themselves and are seen by the developing world.

Concerning the design and implementation of the research program, two questions still remain. First, how can the characteristics and needs of the community be translated into concrete hands-on activities organized as a curriculum? Instructionism, the educational approach that proposes that information needs to be transferred from the teacher to the learner is not always an effective model (Papert, 1993). Constructionism seems to be more appropriate due to the personal investment of the learner and the emphasis on the design and construction of artifacts to make your ideas concrete. The projects created by teachers and children during the workshops, as well as the process they follow to choose, design, and build them, illustrate the methodology of Constructionism. By designing and constructing an external object to reflect upon, people also construct internal knowledge. Constructionism, however, needs materials and an appropriate environment in order to enable construction. The richer the materials, the more potential the learning experience has for the participants.

The second question regarding the research project has to do with the influence of the design and creation of artifacts on the development of the community. During the workshop, both teachers and children were gaining technological fluency, and they were able to externalize the problems and concerns they have in every-day life. The term technological fluency refers to the ability to use and apply technology naturally and efficiently, as one does with language use (Papert & Resnick, 1995). In the case of the RURAL research program, people were able to use the technology to create projects that represent their concerns. Nevertheless, it takes time and persistent hard work to achieve a level of technological fluency, despite the success of the workshops in motivating these discussions and projects. Once acquired, however, it can have a tremendous impact on the way people think, and therefore on the way they behave and make decisions about their lives.

EVALUATION AND FUTURE WORK

There are two types of evaluation for this research program. The first one is the evaluation of the research program itself, which will be done in every phase of implementation. This evaluation will assess changes on people's attitudes towards development, and will identify any new initiatives that emerge from the collaboration between members of the school and the community. This evaluation component will give feedback to the proposal throughout the implementation process. The second one is the evaluation of student's individual progress according to the National Basic Curriculum, which every teacher has to carry out. The former one is expected to infuse changes in the individual evaluation by encouraging the assessment of individual as well as community needs and interests, and the use of those to nourish the curriculum.

The workshops presented in this paper are part of the second phase for the RURAL research program. The assessment and observations proposed in the first phase were never conducted on the community of San Marcos since there were previous assessments and evaluations performed by the LINCOS project. However, a participatory assessment will be needed in order to continue with the implementation of the project in this community and other communities participating in the research program.

ACKNOWLEDGMENTS

I want to thank the ENTEBBE foundation, specially the LINCOS group, for making my work possible with the LINCOS community in San Marcos. I am very grateful to the school principal, the teachers, other members of the community who participated in these workshops and who are still open to further collaboration and work. I am also grateful to my advisor Prof. Seymour Papert for supporting this research program, and to Eleonora Badilla-Saxe for helping me with diverse aspects of the proposal. I finally thank the members of the Epistemology and Learning Group and the LEGO Company for their sponsorship.

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