Using Educational Robots to Enhance the Performance of Minority Students

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Abstract. Social history reports the struggles of minority groups within wider society. The underperformance of these groups in our education system is a persistent concern. Can educational robots contribute to addressing these issues? In this paper Dave Catlin and Professor Sylvester Robertson give shape to this problem by reviewing some of the issue of equity and briefly exploring learning as a cultural practice. They then develop various ERA Principles and show how they provide a theoretic foundation behind RAASP (Robots for African American Students Project).

Keywords: ERA Principles, Equity, Personalisation, Engagement, Robots, Educational Robotics, Assessment, RAASP, African American Education, Cultural Learning.

1 Introduction

Amongst other things, the United Nations convention on the rights of a child states that children have the right to develop:

- Their personality, talents and mental abilities to their fullest potential
- With respect to their cultural identity, language of their community
- For a life in a free society, in the spirit of understanding, peace, tolerance, equality of sexes, and friendship among all peoples, ethnic, national and religious groups and persons of indigenous origin

These are huge statements. Most education authorities in the Western World at least try to do something about achieving these objectives. Yet, the road to success is extremely rocky and is littered with traps, waiting to catch every good intention that sets out. Philosophical, political, economic and sociological issues all conspire to shape the problem. Once defined, we need to find a solution. Our thesis claims that educational robots[1] have a positive contribution to make in helping students of all

[1] We use the term educational robots to define teaching with robots. Teaching about robots we term robotics education.

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pp. 12-21

cultural groups improve their test scores. Educational robots have a positive contribution to make in helping students achieve high test scores. Over the last 30 years Dave Catlin has done a vast amount of unpublished work with educational robots in culturally diverse scenarios. This has persistently shown the value of robots in these situations. Specific projects with Maoris in New Zealand, Aborigines in Australia and Native Americans[2] in Washington State has shown that robots engage minority students and help them make connections with their traditional values. This project aims to formally explore how robots can mediate between minority students and a standard curriculum. This premise is based on the ERA Principles of Curriculum, Engagement, Equity and Personalisation [1]. This paper intends to clarify some of these ideas as part of RAASP. This project is funded and supported by Valiant Technology and Valiant USA. It uses Valiant's Roamer robots. Professor Sylvester Robertson is coordinating the project, with support from three prominent African American Educators: Trina Davies of Texas AM University, Sharnell Jackson, President of Data Driven Innovations and James Smith an independent researcher from Washington State. The project will run four pilots in Los Angeles, Chicago, Texas and Seattle. The paper summarises some of the issues relating to equity and cultural learning. It then provides some background information relating to educational technology, before specifically discussing the ERA Principles. The paper then concludes with a brief statement on RAASP.

Education Equity Policy

Many education organisations have policy statements, concerning equity. We can pick out several issues from these and similar statements [2], [3], [4], [5][3]. :

1. Equity is something we aspire to and strive to achieve
2. Equity involves providing unrestricted access and opportunity to the best education, high expectations and high standards
3. Generally, discrimination is based on: race, ethnicity, linguistic and cultural groupings, political/citizenship status gender, religion, ability/disability, age, social class, and life style

Equity: the Political and Economic Debate

Policy statements declare the democratic intention that each student deserves the "best" education: *that the process should place them at the heart of the education experience*. But what does "best" mean? One candidate is the idea of equal opportunity. Vali et.al. argues, "*…equity places more emphasis on the notions of*

[2] Muckleshoot and Squaxin Island Peoples.

[3] We have more or less randomly chosen statements from a Scottish and US School district, a US National Standard and a small English Education Trust. These are representative of similar statements and policies of most education authorities.

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pp. 12-21

fairness and justice, even if that means the unequal distribution of goods and services"[6]. With the words liberty, democracy, freedom, fairness and justice interwoven in the text, this statement touches the core of the Western values. It becomes political dynamite by suggesting the socialist idea of redistributing resources in order to overcome perceived inequalities.

The mention of 'resources' throws the debate into the political realities of finance. Ex-teacher, author and activist Jonathan Kozol provocatively accuses the American education system of economic apartheid in schools [7]. He cites expenditure of $11,627 per child in New York City, compared with $22,311 in the nearby Long Island suburbs Manhasset. There are those, generally conservatives, who argue that 'money' does not make a difference [8].

Darling-Hammond [9] talks about the inequity of high quality teaching materials, equipment and laboratories. She also cites Ferguson [10] who found that teacher-student ratio of 1:18 was a statistically significant determinant of student outcomes and that black students are more likely than white students to attend schools with larger than average class sizes [11]. Darling-Hammond also cites Robert Dreeben's study of 300 Black and White first graders in Chicago. Students from both groups perform equally well given the same quality of instruction. Statements that students in predominantly minority schools are ten times more likely to have uncertified teachers than those in white schools [12] support Dreeben's claim that minority students are more likely to have poor teachers.

Commentator Paul Coitti presents a right wing counter to this view [13]. He examines the case of Kansas City, Missouri, School District. In 1985 a federal judge intervened in an effort to bring the district into compliance with a "liberal" interpretation of federal law. Over the next 12 years $2 billion dollars was spent. Apparently, the money, made no difference. Catlin and Blamires argue that finance is only one aspect of the problem [2]. What is required in these situations is a systemic change which requires 5 key elements[4]. The Kansas programme only had one of these – resources.

Defining Equity

The Kansas debacle was not helped by an inadequate grasp of equity issues. The Centre for Equity at Manchester University claim that, "*Equity is something that everyone believes in, but that no-one wants to define too closely* [14]. They believe that there is no one way to define what it means.

Equality: Everyone receives the same education, same resources same quality teaching, etc. This supposes that everyone has the same need.

Minimising divergence across a social group: Reducing the achievement gap between the most and the least advantaged social groups by raising the achievement of the lower group. This requires affirmative action and redistribution of resources.

[4] Systemic change requires a vision, buy-in from participants, training, resources and an action plan [14].

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pp. 12-21

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Meeting the needs of all individuals: Differential treatment is required to take account of student diversity. This requires significant resources – both financial and teachers.

While any combination of these perspectives may prevail, experience indicates that equity attitudes within a broad social group often changes to and fro between approaches in a short period of time [15].

Cultural Knowledge

Peter Gordon of Columbia University claims the Piraha tribe of Brazil have no words for number beyond one, two and many. The word for "one" can mean "a few" and "two" can also be used to refer to "not many". He claims their mathematical skill levels are similar to those of pre-linguistic infants, monkeys, birds and rodents [16] He also reports that the tribe members cannot count or draw and standard quantifiers such as "more", "several" and "all" do not exist in their language. The Piraha resist contact with the outside world and believe their culture is superior to anything they have met or heard about. The tribe is perfectly in harmony with itself. It has a foundational, cohesive justification system that works within its own social, cultural and historical environment. It would not work in Manhattan, but Manhattan would not work in the rain forest. What is clear is that the Piraha culture does not have the mental tools, practices, traditions or need to develop or understand, for example, fractal geometry.

The issues relating to the Piraha mirrors the unique and unrepeatable research of Alexander Luria [17]. In the 1930s Luria and other acolytes of the Great Russian developmental psychologist, Lev Vygotsky, studied the peasants undergoing the cultural assault caused by the Soviet Collectivisation programmes. The data collected amongst remote groups of Uzbeks and Kirghiz supported Vygotsky's hypothesis – the very structure of human cognitive processes differs according to their social structures. That is culture provides you intellectual tools you need to learn and develop. A characteristic of both the Piraha and Uzbecks examples was the lack of motivation on the part of the community members to engage in a learning process that had no practical value for them.

Creating Meaning

Professor Stuart Hall describes culture as one of the most difficult concepts in human and social sciences. If you "belong" to a culture you share meanings and values with other members: you

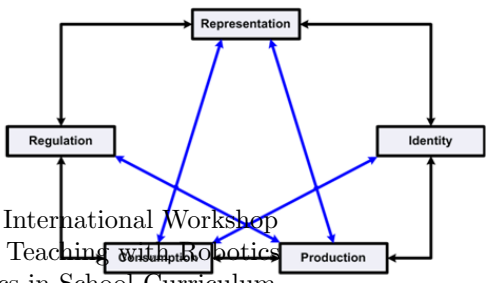

Figure 1 The Circuit of Culture

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pp. 12-21

roughly believe in similar things and interpret the world in the same way. Hall points out: *culture is not so much a set of things – novels and paintings or TV programmes and comics – as process. A set of practices* [18]. Hall explains that shared meanings do not mean that every member of a culture has the same opinion on a topic and that culture is not simply a cognitive process – it is also about feelings, attachments and emotions. The Circuit of Culture illustrates how culture creates meaning [19]. It demonstrates the dynamism of cultures, how they self perpetuate and how they mutate in a complex process. Today's low culture can become elevated to the high art form of tomorrow. For example various classical composers created orchestral works based on traditional folk music[5]. Above all the circuit of culture explains how meaning is created within a social context.

Representation: This is the semiotic systems that forms a culture's signifying practice. It is the basis of conscious and subconscious communications for a cultural group. Language is the major representational (semiotic) system. Others include art, body language, stories, dress codes, rituals, use of technology, etc.

Regulation: This can include formal rules (e.g. government regulations), traditional convention (wearing black at a funeral) or unwritten modes of behaviour. Regulations are not always fixed. A dictionary guides the use of language, but new words or new use of existing words get invented all the time modifying the regulations.

Identity: Individuals identify with one or more groups. This can change and sometime conflict. For example in some circumstances people can bond through gender, but support different football teams. However, peoples identity are created from their cultural participation.

Production: Culture is a living thing, it involves people doing things: producing examples of cultural artefacts, talking, playing music, doing mathematics. To be a cultural member you need to actively participate in the culture.

Consumption: As well as producing culture members of a group consume it. You are what you consume. Culture is not an innate quality: it is acquired by consumption.

Curriculum Equity

In his "best selling" book, Cultural Literacy, American author E.D. Hirsch Jr. proclaimed: *Only by piling up specific, communally shared information can children learn to participate in complex cooperative activities with other members of their community* [20]. If you wish to join the influential intelligentsia of American Mainstream society Hirsch claims you must know his idiosyncratic list of essential knowledge. He claims that his curriculum helps everyone irrespective of their background. It is a sort of cultural lingua franca for all Americans.

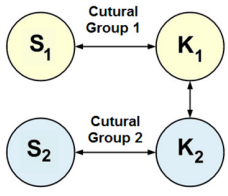

Figure 2: Relationships between students and knowledge.

[5] Brahms (Hungarian Dances); Borodin (Polovtsian Dances); Dvorak (S
(Hungarian Rhapsodies)

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pp. 12-21

The school curriculum does represent a lingua franca across all subjects. It is the product of a WASPish culture. Clearly if you are not a member of this culture it becomes more difficult for you to be successful.

In Figure 2, S represents the students of a cultural group and K is they knowledge derived by the practices of that cultural group. This knowledge is made up from representations and the regulations of that group's cultural circuit. When S_2 students are asked to learn K_1 knowledge they are disadvantaged because they need to approach the problem through K_2 practices. Figure 2 represents an extreme – for example the situation of Luria with the Uzbeks. In most cases the situation of Figure 3 is met. Cultures and cultural practices blend. The severity of the cultural misalignment directly affects the difficulty a minority group faces within mainstream education.

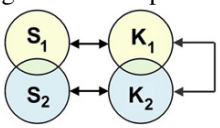

Figure 3: Sub Cultural Relationships.

Communities of Practice

The legendary work of Lev Vygotsky had established the importance of social, historical and cultural factors in learning [21], [22]. But his work concentrated on how these factors affected the individual's cognitive development. In 1991 Jean Lave and Etienne Wenger produced a seminal work which introduced the notion of Legitimate Peripheral Participation (LPP) in a Community of Practice (CoP) [23]. CoP shifts the focus from a description of the cognitive process of the individual to transformative effects of social interactions.

Lave and Wenger were interested in the collective knowledge of the CoP. Their model used the metaphor of an apprentice (newcomer) and master (old-timer). The apprentice started on the periphery of the CoP and learning was a journey towards becoming a full participatory community member. How did the newcomer become a master? What effect did "new-blood" and their journey to full participation have on the collective knowledge and practices of the community? Hall's Circuit of Culture provides good answers to these questions. The student is transformed through the cultural participation and at the same time, the cultural regulations and representations mutate because of the student.

Equity Problem Definition

African American Culture (AAC) is a sub culture within the USA mainstream. This culture is not described solely in terms of ethnicity, but includes the influence of poverty and other social elements that are misaligned with the culture that produced the school curriculum. It is clear that the members of the AAC may not share the goals and objectives defined by the mainstream. Nevertheless, AAC members are, in the main, judged by mainstream criteria. Clearly, some of the issues inherent in this analysis depend on the unfolding of social evolution. Insisting that AAC members chase the dream of straight As disregards some aspects of the UN's charter on children's rights. However, for pragmatic reasons we restrict our objectives. RAASP

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pp. 12-21

accepts the curriculum as it is generally expressed by the various school authorities. It concerns itself primarily with helping African American students getting more out of school study.

How Can Robots Help?

While all the ERA Principles are relevant, we focus on four:

1. Curriculum: Educational Robots can facilitate teaching, learning and assessment in traditional curriculum areas by supporting good teaching practice.
2. Engagement: Through engagement Educational Robots can foster affirmative emotional states and social relationships that promote the creation of positive learning attitudes and environments, which improves the quality and depth of a student's learning experience.
3. Equity: Educational robots support principles of equity of age, gender, ability, race, ethnicity, culture, social class, life style and political status.
4. Personalisation: Educational robots personalise the learning experience to suit the individual needs of students across a range of subjects.

For now we rely on a number of empirically based maxims:

1. Robots are tools that allow students to express themselves from their cultural perspective
2. Students form relationships with robots that are deeply personal [24]
3. The creative nature of robot activities makes them amenable to cultural modification
4. Most cultures have a tradition of artificial life [25] as seen in their myths, stories, puppet theatre, etc. this leads us to believe that robots will be broadly accepted as artifacts by most cultures
5. The notion of body geometry identified by Papert recognizes the role of robots as transitional and relational objects, which makes robots good tools which students can use to explore **their** ideas from **their** perspectives [26]
6. The nature of children's play indicates the power of mimesis transcends cultural boundaries [27]

Educational Robots Activities

The starting point of RAASP is the creation of culturally relevant activities. Robots derive their curriculum prowess from what teachers and students do with them. A number of researchers have outlined issues that grow out of the equity and cultural concepts described above [28], [29], [30], [31], [32]. These publications point out a number of seminal characteristics:

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pp. 12-21

1. The importance of prior knowledge on the performance of students
2. The need for students to be able to apply their cultural filters to study materials
3. The necessity of situating the activity within a culturally appropriate framework

This last requirement poses interesting dilemmas for instructional developers. Nasir et. al. [30] cite the experience of two third grade students in a science lesson. They were asked, "Do plants grow everyday?". Student M from a mainstream background approached the question through experimentation. The ethnic student E imagined her own growth and the "crinkly feeling' she gets when she starts to outgrow her socks. Clearly M's answer is what curriculum demands. But does this mean E's view has no value? Nasir et. al. argue that in practice it does, but in reality it should not. They discuss the sense making practices of scientists – that is the mental models they create for themselves. This is an understated aspect of science. For example most people imagine and atom in terms of a planetary system. That is our mental metaphor. It is not actually like that – it's just the way we think about it. Es imagination is certainly part of what scientists do. If M did not imagine, it is reasonable for us to assess her scientific expertise as limited. Our systemic problem is that M's inadequacy is less likely to be measured on a test than E's. We are not saying that E should not grasp the scientific method, but the necessity of valuing what she does understand and building on it.

Valiant's experience with Roamer® is that it has a particular role to play in helping student to develop effective ways of thinking about things. This is extremely personal and culturally entailed. Moreover, these models often are foundations of a building which leads to formal understandings based on clear mental models.

Bouillion and Gomez [31] cite another type of common example. They argue, *"…artifacts some with a set of cultural entailments, representing goals, expectations, histories, values and practices associated with a particular community of practice. Left unquestioned, these may inadvertently clash with the entailments of a community…"* They discuss the experience of two ethnically diverse communities approaching a project. The mainstream community could relate to the way the project was proposed. To them it was an authentic learning scenario and it motivated the students. The context was alien to the ethnic community. Consequently, as Luria demonstrated they did not see the point. Although projects may develop the same skills, their context is critical to student motivation and performance. Our claim is that robots offer a technology that all communities can own. Robots are flexible enough to present themselves in a ways relevant to different communities.

RAASP

This project will:

1. Create a series of activities aimed at delivering a number of key STEM learning objectives

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pp. 12-21

2. The learning objectives will be topics which African American Students typically find problematic
3. The activities will be culturally situated and presented with appropriate design entailments

At this stage we have not developed activities. Our main focus is on the researching and an in depth analysis of specific education problems that arise out of cultural issues. We will then devise activities to resolve these problems in conjunction with students and teachers at the partner schools. Our objectives are to monitor the work and results of these projects and see how they support or modify the various claims we make in this document.

References

1. Catlin, D. and Blamires, M. (2010). The Principles of Educational Robotic Applications (ERA): A framework for understanding and developing educational robots and their activities, In Press.
2. South Lanarkshire Council: Scotland (2007) Education Resources: Race Equality Statement of Commitment.
3. From the Equity and Civil Rights Office, OSPI State of Washington
4. NCTM (2000) Principles and Standard for School Mathematics. National Council for Teachers of Mathematics. http://standards.nctm.org/document/chapter2/index.htm (accessed 3 March 2012)
5. Equity Statement of the Ruskin Mill Education Trust, Gloucestershire, England. http://www.rmet.org.uk/ (accessed 3 March 2012)
6. Valli, L., Cooper, D., Frankes, L. (1997) Professional Development: Schools and Equity: A Critical Analysis of Rhetoric and Research. Review of Research in Education, Vol 22 pp251 to 301. pub American Educational Research Association.
7. Kozol, J. (2005). The Shame of the Nation: The Restoration of Apartheid Schooling in America. New York: Crown Publishers.
8. Efficiency, Equity, and Local Control--School Finance in Texas. ERIC/CUE Digest, Number 88. (ED357130) citing Cardenas, J. A. (1992, July). Myths and issues in school finance. Paper presented at the Summer Conference of the Institute for Urban and Minority Education, Teachers College, Columbia University, New York, NY.
9. Darling-Hammond, L. (2005) New Standards and Old Inequalities: School Reform and he Education of African American Students pp 197-223 in King, J. (Ed) Black Education, American Educational Research Association pub Lawrence Erlbaum Associates.
10. Ferguson, R.F. (1991) Paying for Public Education: New Evidence on how and why money matters. Harvard Journal on Legislation. 28(2), 465-498
11. National Center for Educational Statistics (1997) America's Teachers: Profile of a profession. 1993-1994 Washington DC: US Department of Education.
12. Shields, P.M., Esch, C., Humphrey, D.C., Young, V.M., Gaston, M., and Hunt, H. (1999) The Status of the teaching profession: Research findings and policy recommendations. A report to the Teaching and California's Future Task Force. Santa Cruz, CA: The Center for the Future of Teaching and Learning.
13. Ciotti, P. (1998) Money And School Performance: Lessons from the Kansas City Desegregation Experiment. Cato Institute http://www.cato.org/pubs/pas/pa-298.html

Proceedings of 3rd International Workshop
Teaching Robotics, Teaching with Robotics
Integrating Robotics in School Curriculum
Riva del Garda (Trento, Italy) April 20, 2012
ISBN 978-88-95872-05-6
pp. 12-21

14. Thousand, J.S. and Villa, R. A. (1995) *Managing Complex Change Towards Inclusive Schooling*. In Thousand, J.S. and Villa, R. A (1995) Creating an Inclusive School. Association for Supervision and Curriculum Development (ASCD).

15 Davis, E (Presenter) (2005) Comp - Prog 1: Pioneers; Prog 2: No More Sheep and Goats; Prog 3: The Blackest Day? and Prog 4: Fourty Years On. BBC Radio 4. http://www.bbc.co.uk/radio4/history/comp.shtml

16 Gordon, P.F. (2004). Numerical cognition without words: Evidence from Amazonia. *Science*, 306(5695), 496–499.

17 Luria, AR. 1982 Cognitive Development: It's Cultural and Social Foundations, Harvard University Press.

18 Hall, S. Editor (1997) Representation: Cultural Representations and Signifying Practices. Sage Publications in association with the Open University.

19 Du Gay, P; Hall, S; Janes, L; Mackay, H; and Negus, K.(1997) Doing Cultural Studies. The Story of the Sony Walkman. Sage Publications in association with the Open University.

20 Hirsch, E.D. Jr. (1988) Cultural Literacy: What Every American Needs to Know, Vintage Books

21 Vygotsky, L.S. (1986) Thought and Language. MIT Press.

22 Vygotsky, L.S. (1978) Mind in Society: Development of Higher Psychological Processes. Harvard University Press.

23 Lave, J. Wenger, E. (1991) Situated Learning: Legitimate peripheral participation. Cambridge University Press.

24 Turkle, S. Taggart, W. Kidd, C.D. and Daste, O. (2006) *Relational Artifacts with children and elders: the complexities of cybercompaionship.* Connection Science Vol. 18 No. 4 p347-361

25 Simons, G. (1986) *Is man a robot?* John Wiley and Sons.

26 Papert, S. (1980) *Mindstorms: Children, Computers and Powerful Ideas*, (p11 and 160) Basic Books.

27 Goldman, L.R. (1998) *Child's Play: Myth, Mimesis and Make Believe*, Berg.

28 Lee, C.D. (2005) Intervention Research Based on Current Views of Cognition and Learning, p73-115, Black Education Edited by King, J.E. published by the American Education Research Association by Lawerence Erlbaum Associates.

29 Bransford, J. D. Brown, A. L. and Cocking, R. R. Editors (2000), *How People Learn: Brain, Mind, Experience and School*. (p57) National Research Council.

30 Nasir, N.S., Roseberry, A.S., Warren, B., Lee, C.D. (2006) Learning as a Cultural Process: Achieving Equity Through Diversity. In The Cambridge Handbook of Learning Sciences, Edited by Sawyer, R.K. pub Cambridge University Press.

31 Bouillion, L.M., Gomez, L.M. (2001) The Case for Cultural Entailments and Genres of Attachement in the Design of Educational Technologie p 331 to 349 in Smart Machines in Education Edited by Forbius, K.D. and Feltovich, P.J. MIT Press.

32 Gay, G. (2000) *Culturally Responsive Teaching: Theory, Research and Practice.* Teachers' College Press.

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