Adaptation to Visitors' Visiting and Cognitive Style

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1. Introduction

Aiming at developing educational/learning technologies for museum use, we soon became interested in the possibility of adapting the museum learning material to the visitor's needs and especially learning needs within a museum. We are looking for quick and efficient ways to provide the visitor with appropriate learning content. The option of adaptivity seems very promising due to the fact that the available time for learning within a museum is very limited both because a person might only visit once and also because a typical visit does not usually exceed some minutes. For example, Falk (1991) found that a typical family visit lasted from 31 minutes to 105 minutes, from which the orientation period was between 3-10 minutes, the intensive looking period was between 15-40 minutes, the exhibit cruising period was between 20-45 minutes and the leave taking period between 3-10 minutes. Falk, et al. (1985) also found that visitors' had an attention span of 30-45 minutes. After that, their attention dropped rapidly. In another study by Serrell (1998), it was found that 82% of visitors spent less than 20 minutes in different exhibitions (110 in total) of various sizes. From all the above, it becomes apparent that the time given for learning is very limited. To this end, it seems important to provide the visitor with personalized experience. Quick adaptivity seems like a good approach to the problem. However, and again due to time restrictions, we do not have the possibility of asking the visitor specific questions that will enable us to identify individual features – a very necessary aspect of the personalization process. We therefore, aim at solutions that will use salient cues to lead to adaptivity without the users' awareness or explicit action. In that light, all information counts whether it is provided by the user intentionally or unintentionally. We believe that we could obtain valuable information about the user by his/her presence in the museum, beyond the primary sources of information that is typically used in adaptive systems (like user's interaction with an interface, direct questions, etc). Secondary informational cues that derive from users' movements, whether they visit alone or in a group, etc. could give us very valuable information that we cannot afford to ignore.

1.1. Visiting Style

One way to gather valuable information from the visitors without interfering with the visit is to observe their visiting style that is the movement of the visitor within the museum environment. Important data come from anthropological research. Veron & Levasseur (1991) identified four types of visiting style, based on the visitors' movement in the physical space of the museum. Visitors were placed in the following groups: ant visitors, fish visitors, butterfly visitors and grasshopper visitors. These metaphors showed the nature of the movement. An 'ant' visitor moves in a clear line, views almost all exhibits, spends a good amount of time for each exhibit, pays attention to details, moves close to the exhibits and the walls, avoids empty spaces, follows the curators suggestions and rationale. A 'fish' visitor moves in the centre of

rooms, does not avoid empty spaces, does not pay attention to details rather shows interest in the 'larger' picture, spends short time in front of the exhibits and does not stop very often. A 'butterfly' visitor does not follow the curators' paths or a clear line in her movement, changes the direction of the movement frequently, usually avoids empty spaces, moves close to the exhibits, sees almost everything, looks at details, seems to be attracted by the exhibit's accessibility, is affected by other visitor traffic (environmental affordances, according to Gabrielli, et al., 1999; Marti, et al., 2001) and stops frequently. Finally a 'grasshopper' visitor seems to have clear preferences and views only the exhibits that interest her. Such visitors do not stop very often, cross empty spaces and they spend a long time in front of the exhibit they choose to see. 'Ant' visitors need the most time to view an exhibition from all other visitors, 'butterfly' visitor follow in time demands, 'fish' visitors need less time than the two above and 'grasshopper' visitors have the shortest visits of all. From the total population of visitors 20% are 'fish', 30% 'ants', 50% 'butterflies' and 10% 'grasshoppers' (Oppermann & Specht, 2000).

2. Applications employing Visiting Style

HIPS (Hyper-Interaction within Physical Space) is a hypermedia system supporting mobile presentation of museum and historical information. Tourists and museum visitors are equipped with a hand-held device which provides electronic tours. Tourists' positions are detected and auditory information is personalized and context depended (Broadbent& Marti, 1997). The main principle of the application is that information is context depended and thus, it should be presented in different ways (Petrelli, et al., 1999). The environment becomes an interface and the visitor's movements become a form of input to the system. The system can spot a novice visitor from her movements and support her during the visit. HIPS assumes that different visiting styles need different durations for the presentations and the empirical data support this hypothesis (Gabrielli, et al., 1999). HIPS is using infrared emitters to connect to the users devices (PDAs) (Marti, et al., 2001). Finally, user testing and evaluation showed that all users liked the idea of receiving information related to their movement. In addition, in the experimental cases where the visiting style was matched to appropriate content, the users demonstrated increased interest by requesting more information about the exhibits explicitly (Marti, et al., 2001).

Hippie is an Internet-based guide supporting the visitor before and during the visit. Over the Internet the visitor can view the exhibits, identify the ones she is most interested in and prepare tours. On site, the visitor's position is tracked down and the different visitors are identified. Hippie then provides personalized auditory information in an attempt to augment the exhibits (Oppermann, et al., 1999). Hippie also records the visitor's movement and places them in user groups according to their visiting style and then combines this information with specific object information and suggests optimal routes (Specht & Oppermann, 1999). Hippie is using infrared installations for the indoor environments and Global Positioning System for the outdoor environments. Oppermann & Specht (2000) suggest that visiting style alone does not have a good predictive power and it should be combined with a taxonomy of the artworks for each space (domain model), with the location of the exhibits in the physical space (space model) and the visitor's interests (user model). Therefore, Hippie is based on a process model of different variables to consider for adequate and efficient adaptivity.

Another system that uses visiting style is VU-Flow, which attempts to solve orientation problems in Virtual Environments and especially in Virtual Museums. The

tool records users' movement in the Virtual Environment and their interactions with it. User's predominant visiting style is identified. The information gathered from VU-Flow allows Virtual Environments designers to easily visualize users' behavior, interests, navigation problems, etc. (Chittaro & Ieronutti, 2004).

3. Limitations of existing applications

We have identified three main areas of possible improvement of the above systems that use the principles of visiting style, if we wish to use similar systems for educational purposes within a museum environment: 1) usability problems could derive from the use of infrared technology, 2) the issues of environmental affordances need further investigation and 3) the content associated with the different visiting styles is on a basic level without further pedagogical concerns, a natural consequence if we keep in mind that the above systems did not have an explicit educational goal. However, in our case, education and learning is a central requirement to the museum experience and therefore, a basic element of the design. For this reason, we need to re-examine issues of visiting style within the scope of education.

1) There are a number of problems associated with the use of infrared technology. Perhaps the most important is the need for a line of sight between the devices, which is sometimes difficult in a museum. Once the connection between the devices is established the visitor should remain stationary in order to receive the entire message, otherwise the transmission will be interrupted. A solution to this problem could be the use of Bluetooth technology, since only the physical proximity is adequate for the establishment of communication (Antoniou & Lepouras, 2005).

2) Although the different researchers (Marti, et al., 2001; Gabrielli, et al., 1999) refer to the environmental issues related to the visiting styles, the environmental affordances and try to actively target the problem (Oppermann & Specht, 2000), we believe that the issue needs further investigation. Valuable factors that allow or not the expression of the visiting styles have been identified like the width of the artworks, their positions, their artistic importance, access points to a room, arches, steps, crowds, lights, etc. (Marti, et al., 2001). We are already investigating issues of museum size, type of visitor and museum type. Museum size might be a very important factor. In a large museum visitors cannot simply see all or most exhibits, therefore, we expect few or not at all 'ant' and 'butterfly' visitors. Similarly, in a small museum, the number of 'fish' and 'grasshopper' visitors might be limited. Perhaps the ideal size for the expression of visiting style is a medium size museum. By the term 'type of visitor' we refer to different visitors that either visit alone or in a group (family, school, friends, and tourists). We have identified 5 visitor types: visiting alone, visiting with family, visiting with friends, visiting with a class (seminar, school, university), and visiting with a tourist group. The type of visitor could significantly affect visiting style. Perhaps the different visiting styles, as Veron & Levasseur have identified them, can only emerge when the visitor is alone. Perhaps different types of group visitors demonstrate different visiting behavior and therefore, have different visiting styles or the proportions of the different styles might be different among the group population once compared to the individuals. Finally, a very important factor might be the museum type. There might be differences in the proportions and expressions of visiting style in museums of different thematic material. For example, in a science museum there might be more 'butterfly' visitors than in a history museum, since exhibitions might not follow a linear presentation.

3) Since the targeted application has an explicit, clear and primary educational and learning core, it is only natural to deal with issues of content. The systems described

above matched visiting style to content based on observations. For example, Chittaro & Ieronutti suggest that 'long and detailed presentations are more suitable for an ant visitor, while short presentations are more suitable for grasshopper visitors' (Chittaro & Ieronutti, 2004, p.46). Empirical data confirm the hypothesis of a correspondence between visiting style and different contents (Gabrielli, et al., 1999), showing a clear potential for efficient learning.

4. Towards a holistic view of museum learning

Umiker-Sebeok (1994) connected visiting style to cognitive style. Umiker-Sebeok (1994) combined the 'butterfly' and the 'grasshopper' to 'leaping' style. 'Ant' visitors for her showed a 'crawling' behavior, and 'fish' visitors showed a 'swimming' behavior. An attempt was then made to link visiting style to cognitive style and the results are very interesting (table 1). As we will discuss later, these findings are very important but the small sample size that was used (only 41 participants), demands further research. However, most systems seem to adopt the Veron & Levasseur approach (i.e. HIPS, VU-Flow). In an attempt to incorporate a strong educational element we decided to investigate the relationship between visiting style and cognitive style further.

Cognitive Style → (N=41) ***Visiting Style*** ↓	**Pragmatic (29%)**	**Critical (17%)**	**Utopian (22%)**	**Diversionary (32%)**
Crawling (46%)	50%	71%	56%	23%
Leaping (44%)	25%	14%	44%	77%
Swimming (10%)	25%	14%	0%	0%

Table 1: Movement patterns and cognitive styles by Umiker-Sebeok, 1994 (from Oppermann & Specht, 2000)

There are number of factors that can significantly influence an individual's learning. Many theories have evolved around this issue and at this point, we will provide a short introduction to the field. We have divided the different factors in two main categories: 1) factors that affect learning and are situation independent and 2) factors that affect learning and are situation dependent (Figure 1)

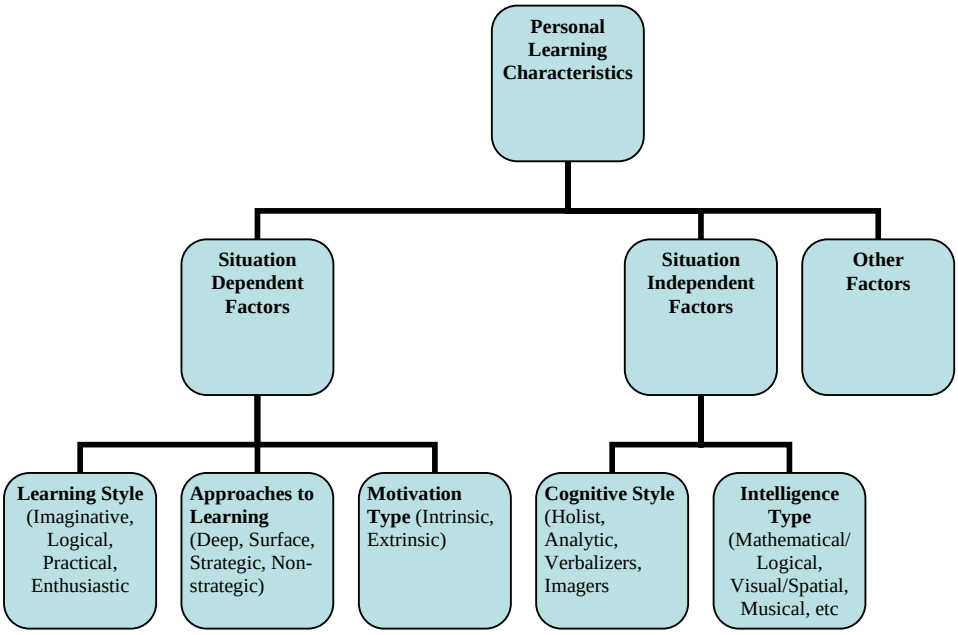

Figure 1. Personal Learning Characteristics

4.1 Individual learning differences: situation independent factors

In the category of situation independent learning characteristics we primarily place cognitive style and intelligence type. The two factors have a strong relation to the individual's personality and they remain relatively constant over situation and time, or at least they are not that easily influenced by the different learning situations.

Cognitive style is a person's preference and habitual approach to the organization and representation of information (Riding & Rayner, 1998). Different researchers have described different aspects of cognitive style. The most common are field dependent-field independent (Witkin, 1962, 1978), impulsive-reflective (Kagan, 1965), divergers-convergers (Hudson, 1966), holist-serialists (Pask, 1972) and verbalizers-imagers (Riding & Cheema, 1991). Cognitive style is a research construct assisting the study of cognitive issues related to learning. There are mixed findings when it comes to cognitive styles and the behavior of users. There might well be mixed-types and especially field-mixed types (Liu & Reed, 1995). However, Students that the learning methods and material matches their cognitive style perform better (Ford, 1995).

Another situation independent learning factor is the intelligence type. Gardener's theory of the seven intelligences implies that people learn in different ways. Traditional teaching cannot address all of these intelligences all of the time. Therefore, a single style of teaching will only appeal to some of the students (Gardner, 1993). Adaptive educational technology could provide a solution to this problem. The different intelligence types are: mathematical-logical, visual-spatial, musical, interpersonal, intrapersonal, bodily-physical and linguistic.

Other situation independent factors are: age, pre-knowledge, maturity, confidence, preferences, background, responsibility, gender, attitudes, working memory[1] and

[1] Differences in working memory capacity seem to significantly influence learning, especially when young and older adults are compared. Some researchers consider working memory capacity as the main reason for individual learning differences apart from domain-specific knowledge (Kyllonen & Christal,

others. There is very limited research concerning these factors and further research is needed.

4.2 Individual learning differences: situation dependent factors

The most used and studied situation dependent learning factors are: approach to learning[2], motivation type[3] and learning style. Learning style is a well studied situation dependent learning factor. Learning style has a situational component as well as an internal, cognitive aspect. There is a terminology issue with the use of the terms cognitive and learning style. The terms are often used interchangeably. This seems natural considering the fact that both terms are constructs for the better understanding of the learning processes. For example, Schmek (1988) uses the term 'learning style' to describe what we previously described as 'cognitive style'. Either approach is 'correct'. It is simply the way different researchers decide to view the subject. It is therefore, important to state our approach. We view cognitive style as a rather stable and constant characteristic that describes the cognitive processes involved in learning. Learning style on the other hand, includes a cognitive component, as well as the situational element. Learning style can thus, change from time to time and from task to task. Cognitive styles do not change very easily and show the cognitive preferences of the individual (i.e. prefers visual information, etc.). In that light, learning style is the different way learners approach the different learning tasks. 'Each individual responds differently to a learning situation. This response will be influenced by the way the individual thinks, her past experience, the demands of the environment and the current tasks. This approach is generally recognized as the individual's learning style' (Atkins, et al., 2001). Perhaps the most known and influential theory about learning style is Kolb's experiential learning theory (1984, 1985).

4.3 Organization of the theories

There have been attempts to organize the different theories of individual learning. Since most research moves around learning and cognitive style, the taxonomies primarily focus on the connections of the two constructs (i.e. McLoughlin 1999[4]). Here, we will briefly mention Curry's Onion Model (1983) that provides a good

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1990). Issues of working memory deserve more investigation especially when it comes to educational technologies.

[2] Approaches to learning seem to be different from time to time and from course to course. An individual could have a deep, a surface, a strategic or a non-strategic approach to the learning situation. Students with a deep approach to learning look for meaning, critically examine evidence, relate new and old information, and show an active interest. Students with a surface approach to learning rely on us, rote learning, focus on the defined syllabus, lack of confidence, do not easily connect old and new information or look for meaning. In a strategic approach to learning a learner seeks qualifications and this is the main motivation, shows increased interest for the course assessment, is competitive and self confident. Students with a non-strategic approach to learning have difficulties to plan their time and learning, are cynical and disenchanted with the material, and jump to conclusions very quickly (Biggs, 1987).

[3] Motivation types are also very influential factors in learning. There are two types of motivation: intrinsic and extrinsic. Motivation that occurs as a natural consequence of the learning process is known as intrinsic. Motivation that occurs due to external influences like assessment and deadlines in known as intrinsic. Intrinsic motivation usually triggers efficient learning (Elton, 1996).

[4] According to McLoughlin, the issue of learning differences and style can be approached from two different directions, from the direction of psychology and from the direction of education. The psychological approach mainly focuses on the cognitive processes involved in learning (the wholist-analytic and the verbaliser-imager continuums, Riding & Cheema, 1991). The educational approach focuses on the individual's ways of learning and the conceptions of it (the experiential learning cycle, Kolb, 1984)

framework for the study of the different theories (Figure 2). The Onion Model has three layers. The outer layer is the easiest to observe but it is also easily influenced by external factors and therefore, not very stable[5]. The middle layer of the onion model is the information processing style. It is the way the learner processes information. This level is more stable than the first, since it does not interact directly with the environment[6]. The inner layer describes the cognitive personality style. This is a relatively permanent and stable level since it is related to personality traits and deeper cognitive processes. The cognitive style dimensions[7] can be placed in this inner layer.

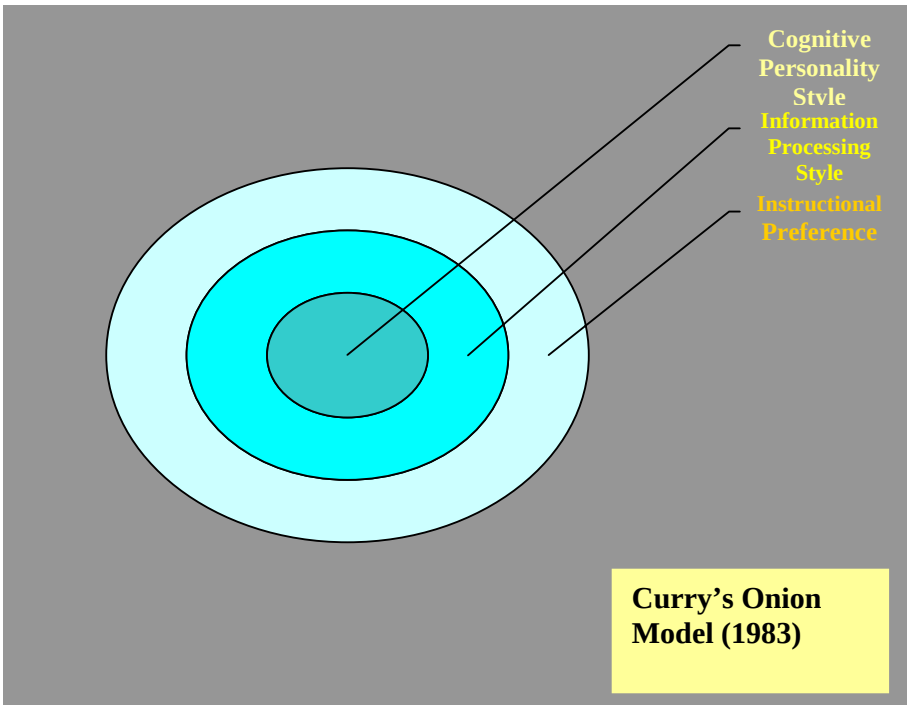

Figure 2. Curry's Onion Model.

5. Assessment Tools

Most of the above theories can assess learning or cognitive style with relevant tools. The widely used assessment tools use two approaches for assessment, they either investigate learner's cognitive processes or they record learners' beliefs about their learning or both. For example, Riding's Cognitive Style Analysis (CSA) records and assesses participants' cognitive performance within a specific time frame and places the learner on the wholist-analytic and the verbalizer-imagery axes (Riding & Rayner, 1998). Another assessment tool is the Kolb's Learning Skills Inventory (KLSI) that

[5] Dunn & Dunn (1978) describe the five groups of factors that can influence a learner's instructional preferences. These are environmental, emotional, sociological, physiological and psychological factors.
[6] Kolb's (1984) theory of experiential learning falls under this layer. Other theories that can be placed in the middle layer are: 1) the Honey & Mumford model (1992) (uses a learning cycle and describes four learning styles: activists, theorists, pragmatists and reflectors), 2) the 4MAT system by McCarthy (1997) (again a learning cycle, the four styles are: innovative, analytic, common sense and dynamic), 3) Gregorc's Style Delineator (1982) (the four styles are: concrete sequential, concrete random, abstract sequential and abstract random), 4) Gardener's theory of multiple intelligence (1993).
[7] The wholist-analytic and the verbal-imagery dimensions (Ridind & Cheema, 1991; Riding & Rayner, 1998), field-dependence/field-independence (Witkin & Goodenough, 1982).

uses participant beliefs in order to determine learning style for the given situation. Finally, a widely used assessment tool for cognitive style is the Myers-Briggs Type Indicator. The MBTI is based on Jung's theory of psychological types and it describes learners on four dimensions based on self-reported questionnaires. The dimensions are extraversion-introversion, sensing-intuition, thinking-feeling and judging-perceiving. The combination of the above dimensions provides 16 possible personality types, with different cognitive preferences and learning needs. The MBTI is mainly used by organizations for employee selection and placement. MBTI has a strong validity and reliability, provided that the participants give honest answers.

In our research, we decided to use the MBTI in order to determine visitors' cognitive style. From all the different factors that affect learning, cognitive style was considered more appropriate in this case because it is a rather constant and stable characteristic. In a museum environment, visiting style is by large, situation dependent. We believe that cognitive style's stability provide a good counter variable for our analysis. The use of cognitive style should be considered as a starting point in an attempt to relate museum learning to individual learning differences. We decided to use the MBTI because it is widely used and easy to complete in a questionnaire. According to Atkins, et al., (2001) the models in the outer and middle layer of the Onion Model cannot be easily used for the development of technology since they do not directly describe cognitive processes responsible for learning. Moreover, there are indications of possible correlation of cognitive and learning style. According to Trevino, et al., (1990) people found as of concrete experience with the KLSI show very similar learning preferences to people characterized as perceptive with the MBTI. Similarly, participants of high abstract conceptualization with the KLSI are very similar to the judging type found with the MBTI. These findings indicate possible correlation between more individual learning differences. For example, some types of intelligence might correlate with cognitive style, motivation levels, etc. the field needs further research.

A very important reason for using MBTI was the fact that it includes questions on user control. For quite sometime there is a debate about the appropriateness of adaptive or adaptable systems. The main question was whether it is better for the user to interact with an adaptive system or whether it is better that the system allows user control and provides choices to the user. The issues of user control are very important for the design of educational technologies. Kettanurak, et al., (2001) found that accommodators (using Kolb's learning styles) appreciated the control given to them and a high interactivity mode, whereas divergers did not like the high user control condition. By specifying participants' control preferences, we will then be able to see the possible connections to the other variables like visiting style. The MBTI seems an appropriate tool for the issues of user control.

6. Factors

So far in our research we have identified 11 factors that seem to affect museum learning. With the use of questionnaires we will study the possible relation between all those factors. These factors will be used for the further design of the adaptive system.

- Age (four possible values- 5-18, 19-45, 46-60, over 60)
- Gender (two possible values- F, M)

- Age of children (five possible values- 0-3, 3-5, 5-7, 7-12, 12-18, based on Piaget's Developmental stages)
- Gender of children
- Nationality
- Museum size (three possible values- small, medium, large)
- Visiting style (Four possible values- fish, grasshopper, ant, butterfly)
- Type of Visitor (Five possible values- alone, school, tourist group, peers, family)
- Museum Type (five possible values- 1. science and technology, 2. children's, 3. art, 4. history, archaeology, and heritage sites, 5. zoos, aquaria, and botanical gardens- based on the classification of Hooper-Greenhill and Moussouri, 2002). There is another classification of the Greek Ministry of Culture, with 10 possible values; however, the classification is not based on learning characteristics of the museums). For the present research we will only use two types, the Archaeological and the Science and Technology.
- Cognitive Style (16 possible values, based on the Myers and Briggs type Indicator)
- User Control (initially only two possible values- prefers control and prefers instructions)

7. Summary

Wishing to investigate issues on museum adaptation, we decided to further study a group of factors like visiting style, cognitive style, user control, age, type of visitor, type of museum, nationality, gender. A solution to the adaptation problem in a museum environment is very important due to 1) the nature of the time restricted visit and 2) the fact that the user-visitor will only use the system once (in the majority of the cases). In contrast to other systems, there is not time to adequately update the user model. Adaptation based on movement can be very useful since there are no questions asked. Together with other parameters like user actions on the interface, time spent in front of exhibits, use of web page, etc. adaptation based on movement could be a good starting point to the problem. The further study of the individual learning differences will hopefully allow us to find the appropriate teaching material for each visitor within the museum environment.

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