

The Effects of the Pedagogical Agent's Instructional Role on Achievement and Motivation among Students with Different Cognitive Styles

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Abstract

This article discusses the findings of a study that elucidated the effects of the pedagogical agent's instructional role towards achievement and motivation among students with different cognitive styles, namely, the field-independent (FI) and the field-dependent (FD) cognitive styles. Two versions of the web-based instruction of a particular course, each with the assistance of a personalised pedagogical agent, namely, one with the Expert Instructional Role (EIR) and another with the Mentor Instructional Role (MIR), were designed and developed to serve the purpose of this study. The participants consisted of 86 fourth year undergraduates from the School of Educational Studies, Universiti Sains Malaysia were divided into two groups and each group was assigned to the learning with the assistance of either the pedagogical agent with the EIR or the MIR. An empirical study based on 2 x 2 quasi-experimental designs was deployed. A comparative analysis was conducted using the independent-samples t-test procedure. Taking the students as a whole, the results revealed that students who were assisted by the MIR agent performed significantly better compared to those who were assisted by the EIR agent, both in terms of achievement and motivation. Among the FI students, the results showed that there was no significant difference in terms of the achievement between students using the pedagogical agent with either the EIR or the MIR. However, there was a significant difference in terms of motivation between the students, with a higher mean motivation score for students using the pedagogical agent with the MIR. Among the FD students, the results showed that there was a significant difference both in terms of the achievement and motivation between students using the pedagogical agent with either

the EIR or the MIR, with higher means for students using the pedagogical agent with the MIR. This study infers that the pedagogical agent with the MIR was more useful compared to the pedagogical agent with the EIR in that the former was able to enhance the motivation among both the FI and FD students more effectively. The pedagogical agent with the MIR was also able to increase the achievement among the FD students better than the pedagogical agent with the EIR, but not among the FI students.

Keywords: human-computer interface, pedagogical agent, instructional role, cognitive style, educational technology; online learning; achievement, motivation.

Introduction

Learning in a web-based learning environment can be more interactive, interesting and motivating with the existence of an on-screen coach, an animated life-like character or a virtual instructor (Kim and Baylor, 2006; Konstantin, Antonija and Lucy, 2007). This virtual instructor, known as the pedagogical agent, can provide instructional interventions so that learning can become more effective and this is even more so if a conversational style of presenting the course content is implemented. As such, the animated pedagogical agent, if carefully designed and developed, can facilitate and support students' learning due to the very nature of the high degree of interactivity that can take place. The pedagogical agent can function as a cognitive tool as well as a communicative tool that guides the learners to experience the web-based instructional materials more effectively. The pedagogical agent also builds social relations, enhancing new beliefs and attitudes, as well as sharing empathy, thus enabling the learners to achieve more skilful performances and acquire more positive attitudes in learning.

The rationale of having a pedagogical agent in the web-based learning environment is for it to serve as a virtual pedagogical instructor to facilitate and to enhance the construction of knowledge. As such, it is imperative that when designing a pedagogical agent, its role within the learning environment must be studied carefully so that it serves the intended instructional purposes. If a pedagogical agent is well-designed with an appropriate persona and media features, it can effectively play a

role as “the virtual human instructor” and can be perceived by learners, as being able to undertake the intended instructional role effectively.

The instructional roles of pedagogical agent and their effects on learning have received immense interest from researchers (Baylor, 2000, 2003; Baylor and Kim, 2003, 2004, 2005; Kim, 2004; Kim and Baylor, 2006; Konstantin, Antonija and Lucy, 2007). These researchers have identified several effective instructional roles for pedagogical agents that are essential in learning, such as the agents as experts, mentors and motivators. Empirical researches have been extensively conducted to validate the effectiveness of the different instructional roles for promoting learning and motivational outcomes within various agent-based learning environments. Baylor (2003) reported that agents with expertise (as experts and mentors) were significantly more credible and led to better performance on the learning transferred compared to motivator agents. Besides, the mentor agent has been perceived as more engaging and more effective in facilitating learning than the other two agents and this has also led to significantly better learning transfer in terms of performance. Baylor and Kim (2005) confirmed that the instructional roles of agents led to significant changes in learning and motivation: the experts led to increased knowledge acquisition, the motivators led to enhanced self-efficacy and the mentors led to overall improved achievement and motivation. Furthermore, Baylor (2003) emphasised that it is important that the agents should have both expertise and motivation in the support of learning.

In terms of the pedagogical agent as a virtual instructor to promote learning and motivational outcomes, two instructional roles that fit into the characteristics of an ideal instructor are those of the expert and the mentor. Experts are persons who are very skilful in, or knowledgeable about, particular areas. Generally, they exhibit mastery and possess extensive knowledge within a particular domain of knowledge. Moreover, they are usually confident, stable in performance and not easily influenced emotionally by internal or external conditions. Mentors, on the other hand, are individuals who are experienced in specific areas and they serve as trusted advisors. Usually, mentors work collaboratively with learners to achieve goals. As an ideal instructor, a mentor does not simply provide information but rather, provides guidance for the learners to bridge the gap between the current and

desired skill levels (Driscoll, 2000). At the same time, mentors develop a social relationship and a strong rapport with the learners to motivate them to perform better.

Apart from the instructional design of the course content, the graphic design and a highly realistic pedagogical agent, learning outcomes also depend on the characteristics of targeted learners. Kim and Baylor (2006) stated that different permutations of agent-learner interaction might be advantageous but only if the learner characteristics and the task-at-hand were considered in the design of the pedagogical agent.

In the analysis of the learners, two broad types of human characteristics should be taken into consideration, namely, the individual differences and individual similarities. Widely studied factors of individual differences include the intelligence quotient (IQ), cognitive styles, psychosocial traits, developmental stages and prior learning. On the other hand, individual similarities are aspects that are characterised by relative similarities among people rather than differences (e.g., sensory capacities, information-processing capabilities, human cognition and developmental processes).

In this study, the focus was on the individual differences in terms of the cognitive styles, namely, the field-independent (FI) and field-dependent (FD) styles (Witkin et al., 1977). The cognitive dimension of field-independent/dependent (FI/FD) generally refers to the learners' manner of processing information on a continuum between the analytical and the global. The cognitive style also refers to the individual's consistent and characteristic tendency of perceiving, remembering, organising, processing, thinking and solving problems. The cognitive style (FI/FD) is an important individual difference to be studied as it provides information about individual differences from a cognitive and information-processing standpoint.

The FI learners tend to be intrinsically motivated and enjoy individualised learning while the FD learners tend to be extrinsically motivated and enjoy cooperative learning. In terms of cognitive restructuring, FI learners are more autonomous in relation to the development of cognitive restructuring skills compared to the FD learners. However in the case of interpersonal skills, the FD learners are

identified as more autonomous compared to the FI learners. Generally, it is likely that the FD learners may require more guidance from the instruction to perform a task successfully compared to the FI learners.

Due to the importance of the characteristics of the pedagogical agent for instruction and its relation to the cognitive style of the learners, this study attempted to look at the effects of these two variables in terms of the achievement and motivation. Specifically, the research questions of this study were as follows:

1. Taking the students as a whole, which pedagogical agent's instructional role is better to serve the purpose of enhancing achievement and motivation?
2. Among the FI students, which pedagogical role is more effective in serving the purpose of enhancing achievement and motivation?
3. Among the FD students, which pedagogical role is more effective in serving the purpose of enhancing achievement and motivation?

The Study

This study seeks to investigate the most effective instructional role of the pedagogical agent to optimise the achievement and motivation among students with different cognitive styles (FI/FD). Firstly, two versions of a personalised pedagogical agent with different instructional roles, namely, the Expert Instructional Role (EIR) and the Mentor Instructional Role (MIR), were designed and developed (refer to Figure 1) using the SitePal Virtual Avatar Creator.

The appearance of the MIR and EIR are of slightly western looks due to the limitation of appearances within the Sitepal System. The look of the EIR was made more authoritative and knowledgeable whereas the look of the MIR was made more friendly and motivating. The verbal cues from EIR and MIR were designed in such a way that they followed their instructional roles. The appearances and the verbal cues were verified in the pilot test. Even though the western looks were not the natural look of the participants, we were confident that this look has no influence on the outcomes of the study as indicated in the pilot test.

Meanwhile, an online learning material entitled “The Cognitive Theory and Design of Multimedia Instruction” was developed in the Moodle Learning Management System (LMS) to serve as the instructional material for this study. Subsequently, the developed agents were integrated into the LMS to produce the pedagogical agent-based learning environment within the LMS as the delivery platform (refer to Figure 2).

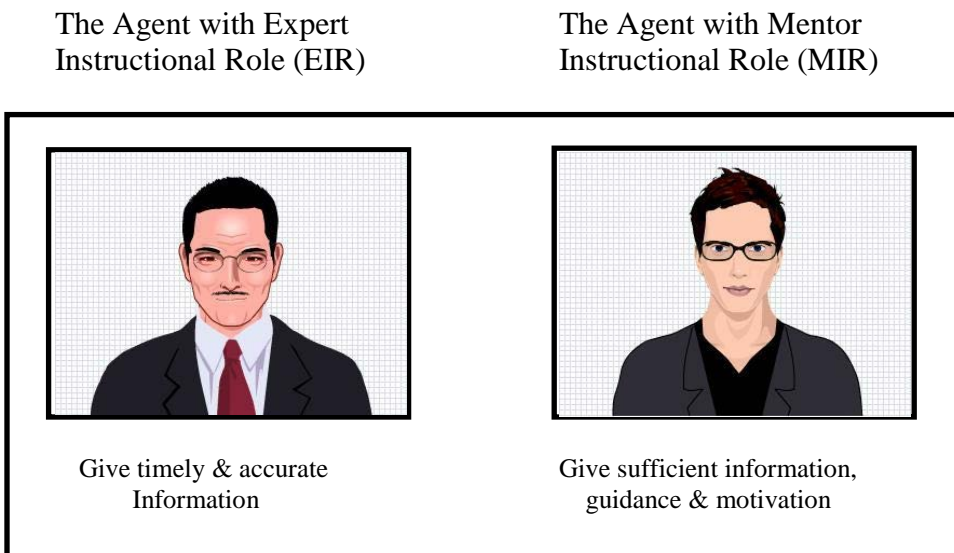


Figure 1 Two versions of pedagogical agent with instructional roles

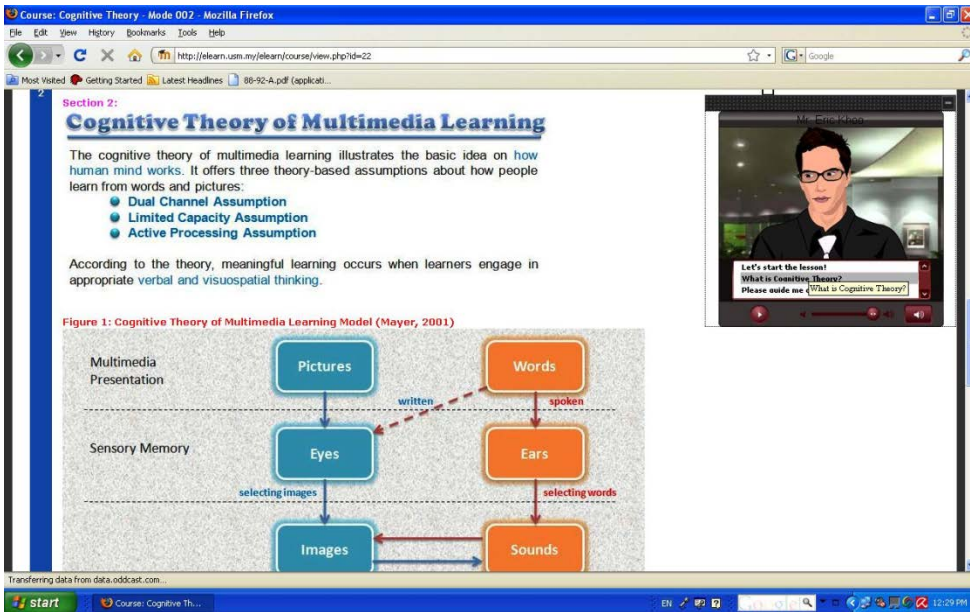


Figure 2 A screen display of a pedagogical agent-based learning environment

Secondly, a systematic experiment was planned and carried out to examine the effects of the different instructional roles of agent on achievement and motivation among students with different cognitive styles (FI/FD). In this study, the independent variables were the agent’s instructional roles (EIR and MIR), while the achievement and motivation score were the dependent variables. The students’ cognitive styles (FI and FD) were the moderator variables.

Methodology

Research Design

This study utilised a “2 x 2” quasi-experimental research design to determine the students’ achievement and motivation. The impact of the independent variables (the agent's instructional roles) towards the moderator variables (the students’ cognitive styles) was investigated (refer to Figure 3).

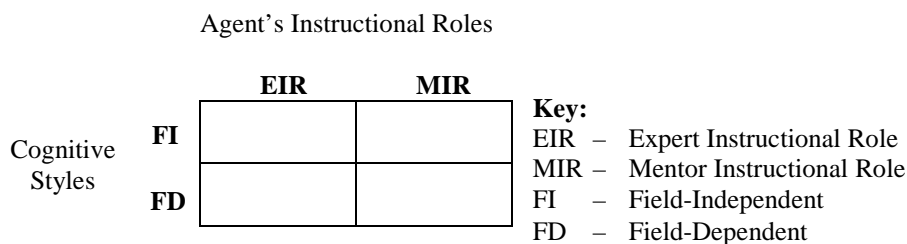


Figure 3 The Quantitative ‘2 x 2’ Quasi-Experimental Research Design (Agent’s Instructional Roles x Cognitive Styles)

Participants

The participants of this study consisted of 86 fourth year undergraduate students from the School of Educational Studies, Universiti Sains Malaysia (USM), who enrolled in the “ICT in Education” course. Their age ranged from 21 to 37 years, with the mean of 22.73 years and the standard deviation of 1.818 years. They are culturally diverse in terms of ethnicity with majority of them are indigenous Malay along with few Chinese and Indians. As the EIR and MIR are with European looks, we feel that the ethnicity variables of the study would have no impact the outcomes. The participants were also told that they were participating in the study and their opinions were strictly confidential. There was no intrusion into their privacy and had no impact on their course assesment.

Instruments

Three main instruments were administered to the participants. The first instrument was the Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin and Karp, 1971). This test was used to determine the cognitive styles of the students and to group them into the field-independent (FI) and the field-dependent (FD) cognitive styles accordingly. The second instrument was the Intrinsic Motivation Inventory (IMI). It was deployed to measure the students’ level of intrinsic motivation towards the instruction. A set of pre-tests and post-tests was used as the third instrument to measure the achievements of the students before and after the treatment.

This experiment was divided into three consecutive stages: the pre-experiment, experiment and post-experiment (refer to Figure 4). In the pre-experiment stage, the students were required to undergo the pre-test and the GEFT. The students were grouped according to their cognitive styles (FI/FD) based on their accumulated scores in the GEFT. Students who scored above the mean score ($\mu=11.65$, $SD= 4.124$) in the GEFT were referred to as the FI students whereas students who scored below the mean score were identified as the FD students.

The experiment was conducted three weeks after the completion of the pre-experiment. During the experiment, the students were randomly assigned to the web-based learning environment with the assistance of an appropriate pedagogical agent with either the EIR or the MIR. The students were required to study the instructional materials provided in the LMS and at the same time, they interacted with the assigned pedagogical agent for the duration of an hour.

Research Procedures

The post-experiment stage was conducted immediately after the experiment stage. The students were given the IMI and the post-test. The achievement score (post-test score minus pre- test score) and motivation score (IMI score) were collected and calculated. The independent- sample t-test procedure was performed to compare the achievements and motivation between the students assisted by the pedagogical agents with the two roles.

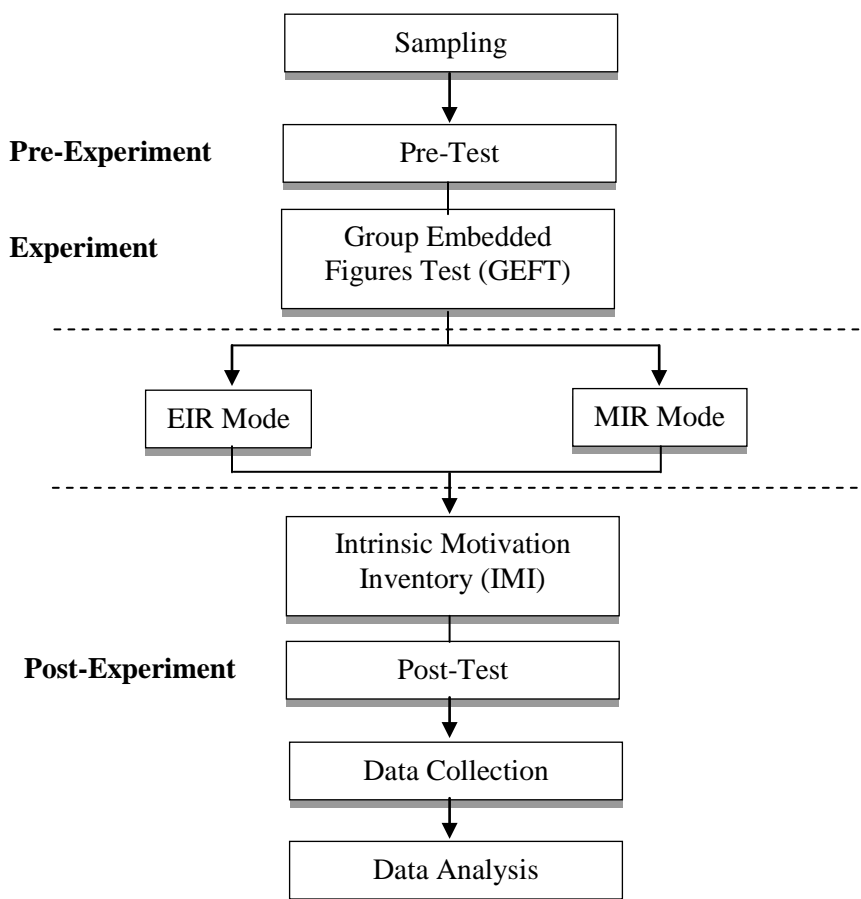


Figure 4 Research procedures

Results and Discussion

Effects of the Agent's Instructional Roles Towards Achievement and Motivation Scores

Table 1 shows the data which compare the mean of the achievement scores and the mean of the motivation scores achieved by the students between the groups that utilised the pedagogical agent with the EIR, and the group utilising the pedagogical agent with the MIR. The significant values (p -values) were obtained by comparing the means between mean scores using the independent-sample t -test.

Table 1 Differences between groups using the independent-samples t-test

	Independent Mode	N	Mean (μ)	SD	Sig. (p -value)
Achievement Score	EIR	42	10.50	4.900	0.016*
	MIR	44	12.82	3.662	
Motivation Score	EIR	42	130.24	17.025	0.002*
	MIR	44	141.25	14.216	

*Significant at $p < 0.05$

The result revealed that students who utilised the pedagogical agent with the MIR in their learning performed significantly better ($p=0.016$) compared to students who used the pedagogical agent with the EIR as indicated by the higher mean in the achievement score of the former. This finding conformed to the results obtained from several studies such as that conducted by Baylor and Kim (2004). Learning would be enhanced with the guidance and sufficient information provided by the pedagogical agent with the instructional role of a mentor. Such guidance would help the students to gather important information required for their learning. In addition, formal and redundant information without guidance provided by the pedagogical agent with the EIR may have confused the students and interrupted the construction of knowledge, leading to lower mean scores in the achievement.

The results also showed that students who used the pedagogical agent with the MIR performed significantly better ($p = 0.002$) compared to students who used the pedagogical agent with the EIR in terms of the mean motivation score. The students were more motivated when they interacted with the pedagogical agent with the MIR. This was because this pedagogical agent provided motivational words and encouragement in the communication. Therefore, the agent could sustain the attention of the students towards the instructional materials. This result supported the previous findings of Baylor (2003). The role of the mentor is significantly more engaging and facilitative compared to the role of the expert in the instructional process. In the study, this was reflected in significantly better achievement scores and motivational outcomes as depicted in Table 1.

Effects of the Agent's Instructional Roles on Students of Different Cognitive Styles (FI/FD)

The participants were divided into two groups of cognitive styles (FI/FD) based on their accumulated scores in the GEFT. The distribution of the participants into these two groups and into two different sub-groups in terms of the instructional roles of the pedagogical agent (EIR/MIR) is shown in Table 2.

Table 2 Distribution of groups based on cognitive styles

Modes of Presentation	Cognitive Style		
	FI	FD	Total
EIR	28	14	42
MIR	23	21	44
Total	51	35	86

The independent-sample t-test was conducted to compare the means of the achievement scores and the means of the motivation scores between the two groups (refer to Table 3). The significant values (p -values) were obtained by comparing the means between the two groups.

Table 3 Differences between groups using the independent-samples t-test in terms of different cognitive styles

	Group	N	Mean (μ)	SD	Sig. (p -value)
Achievement Score	FI-EIR	28	11.57	4.710	0.493
	FI-MIR	23	12.39	3.513	
	FD-EIR	14	8.36	4.717	0.002*
	FD-MIR	21	13.29	3.849	
Motivation Score	FI-EIR	42	130.24	17.025	0.002*
	FI-MIR	44	141.25	14.216	
	FD-EIR	14	130.71	12.449	0.045*
	FD-MIR	21	140.33	14.644	

*Significant at $p < 0.05$

Effects of the Agent's Instructional Roles on Field-Independent (FI) Students

In the case of the FI students, the result showed that there was no significant difference ($p = 0.493$) in the mean achievement score between the students who used the agent with the MIR (FI-MIR) vis-à-vis those who used the agent with the EIR (FI-EIR). In contrast, the results showed that the FI students who used the agent with the MIR (FI-MIR) performed significantly better ($p = 0.015$) than the FI students who used the agent with the EIR (FI-EIR) in the mean of the motivation scores. As the experiment was conducted under a control experimental setting, the results positively inferred that the agent's instructional role as the mentor made a more significant contribution towards increasing the learning motivation of the FI students, but this was not the case where the achievement scores were concerned. A probable reason could be the inherent nature of the FI students in that they were able to perform the learning tasks independently even without much guidance or help from the instruction. In addition, the inherent nature of the FI students was such that they tended to be intrinsically motivated and enjoyed individualised learning. As such, the instructional role of the agent had little influence on the achievement of these students.

Effects of the Agent's Instructional Roles on Field-Dependent (FD) Students

In the case of the FD students, there were significant differences in the mean of the achievement scores ($p = 0.002$) as well as in the mean of the motivation scores ($p = 0.045$) between students who used the pedagogical agent with the MIR (FD-MIR) and those who used the pedagogical agent with the EIR (FD-EIR). This implied that the FD-MIR group performed significantly better as there was sufficient guidance, information and encouragement provided by the pedagogical agent with the MIR. These elements of support were essential to optimise learning for the FD students. The results supported previous findings which showed that the FD students needed more help to perform the learning tasks effectively and successfully than the FI students. Besides, the FD students enjoyed cooperative learning and performed better with the presence of extrinsic motivation provided by the mentor.

Conclusions

Taking the students as a whole, the results of this study revealed that the pedagogical agent with an instructional role as a mentor benefits learners both in terms of the achievement as well as in the motivation compared to the pedagogical agent with an instructional role as an expert. This implied that the mentor instructional role is preferable over the expert instructional role when designing the pedagogical agent in the web-based learning environment. This could be due to the very nature of the role of the mentor – providing adequate knowledge that leads to enhanced achievements as well as guidance which improves the motivational aspects to the learners during the instruction.

When the cognitive learning styles of the students were taken into consideration, the greatest impact of the mentor instructional role of the pedagogical agent was observed on the field- dependent students. Specifically, this role significantly increased both the achievement as well as improved the motivation among the field-dependent students. The impact on the field- independent students was less as the enhancement was seen in terms of only motivation but not in terms of the achievement.

There were several limitations in this study. Firstly, the selected instructional roles of the agent were limited to those of an expert and mentor only. More studies can be carried out by experimenting on other instructional roles such as those of the motivator, facilitator, counsellor and peer. Secondly, the study was conducted with undergraduate students as the participants. The experimental effects of the agent's instructional role would differ for participants with a different range of ages. Thirdly, the learning course contents were designed specifically for the acquisition of knowledge and the understanding of concepts and principles, which could be a limitation as different instructional roles serve well for different instructional strategies and intended outcomes.

Future research on agent-based instructions can be extended to investigate other potential instructional roles of pedagogical agents as virtual instructors that could benefit learners with different psychological profiles. In addition, research could also examine the effects of the agent's instructional role on different individual differences such as

intelligence levels, psychosocial traits, ethnicity, gender and developmental stages.

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