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ABSTRACT

The purpose of the study reported in this paper was to describe adolescent motivational processes. Early adolescents (N=137), their accompanying adults, and venue staff members were interviewed and observed in specific informal science education venues. A typological analysis of the data revealed: (1) activities by early adolescents take place within social groups that mirror stages in the development of self-regulated behaviors, (2) adolescents displayed a primary intrinsic motivational process as well as a linked secondary motivational process which was generally an instrumental or consummatory process, (3) evaluations of experiences within the venues contained elements of intrinsic motivational processes as well as instrumental and/or consummatory processes, and (4) adolescents in each venue went through similar types of motivational processes and actions. Next the constructions were translated into salient constructs which were used to develop a vignette-based questionnaire which was administered to 45 adolescents in the original sites and also used to develop motivational instructional approaches in formal science education environments. Results from the formal environment were nearly identical to those in the informal environment on all six constructs. Contains 65 references. (Author/JRH)

Parallel Courses: Comparison (and Convergence) of Adolescent Motivational Processes in Informal and Formal Science Education Settings

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Paper presented at the 69th Annual Meeting of the National Association for Research in Science Teaching, St. Louis, MO, April 2, 1996

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ABSTRACT

Studies of adolescent motivation in formal science education (FSE) environments have largely been limited to the administration of generalized expectancy-value (E-V) based questionnaires that attempted to measure motivation towards science without considering the specific context. The E-V basis for motivation can be expanded upon by considering both the antecedents (social cognitive development or SCD) and the consequents (actions) of motivational processes. Adolescents participating in specific informal science education (ISE) venues were assumed to be motivated to engage in science learning activities. In order to describe adolescent motivational processes, this study consisted of four main phases. In Phase I, 3 ISE venues (3 science/technology centers, 4 science-dedicated stores, 2 go-kart races) were selected. In Phase II, a total 137 early adolescents, their accompanying adults, and venue staff members were interviewed and observed. A typological analysis of these data revealed: (1) activities by early adolescents take place within social groups that mirror stages in the development of self-regulated behaviors, (2) adolescents displayed a primary intrinsic motivational process as well as a linked secondary motivational process which was generally an instrumental or consummatory process, (3) evaluations of experiences within the venues contained elements of intrinsic motivational processes as well as instrumental and/or consummatory processes, and (4) adolescents in each venue went through similar types of motivational processes and actions, different venues facilitating different strands in a motivation-action-SCD cycle. In Phase III, the constructions were translated into salient constructs: relatedness-involvement, autonomy-autonomy support, competence-effectance, and situation-specificity. A vignette-based questionnaire developed from these constructs was administered to 45 adolescents in five of the original ISE sites. In Phase IV, areas of convergence with respect to the motivational constructs were sought between the ISE venues and FSE environments where the teachers had developed motivational instructional approaches, using the questionnaire tested in Phase III. The results of the Phase IV administration to 95 adolescents in FSE environments were nearly identical to those in Phase III on all six constructs. Further investigations will determine if the constructs represented by this convergence are malleable or general to adolescents regardless of their instructional environment.

Introduction

Adolescent motivation towards science learning has been cited as a source of concern by the science education community (Pascarella, Walberg, Junker, Haertel, 1981). Many teachers have found difficulty in motivating their students to engage in the learning opportunities offered in school science (Richardson, 1994). Yet it seems that some teachers are intuitively able to motivate their students, both in the science classroom and beyond. The purposes of this investigation are to: (1) define what motivates early adolescents to engage in science learning free of a formal school environment and (2) determine if science teachers that do motivate their students to engage in science learning in school are generating an instructional environment that elicits the same type of motivational response seen in early adolescents in informal learning environments. If teachers are to promote self-regulated learning, as Paris & Turner (1995) state, then "it is critical for researchers to identify how and why some situations evoke positively motivated behaviors and some do not" (p. 217).

Studies that have been done on adolescent motivation for science learning have largely been limited to achievement motivation or attributions within the science classroom (Anderman & Young, 1994; Gottfried, 1985; Haladyna & Shaughnessy, 1982), yet neglect science learning situations outside the classroom (Falk, Koran, & Dierking, 1986). Adolescent motivation has been examined in individual museum environments (Ernst & Young, 1990, 1991, 1992; Salmi, 1993), but not across several ISE environments. The theoretical frameworks of these studies are largely rooted in traditional expectancy-value descriptions of motivation, without considering the context-specificity in an action-theoretical or developmental perspective. The problem of detecting adolescent motivational processes, I believe, is more complex than is reached by simply administering a generalized questionnaire. One should consider not just indications of the process, but what conditions led up to and subsequently followed the execution of such motivational processes. Therefore, the adolosecent motivational process that were detected were done so from the perspective of a motivation-action-social cognitive development cycle. This study is a continuation of the work represented in Pyle (1995), showing close parallels between the constructs generated from data collected in informal science education (ISE) settings and the responses of students in motivational formal science education (FSE) environments.

Theoretical Frameworks

Motivation

Motivation in general can be described as, "a variety of [cognitive] processes and effects whose common core is the realization that an organism (1) selects a particular behavior because of some expected consequences, and then (2) implements it with some measure of energy, along a particular path." (Heckhausen, 1991, p.9). All aspects of motivation have at their core the notion of expectancy and value (Tolman, 1952). Expectancy-value relationships for an individual are inseparable from the situation or context in which the motivational process occurs

(Heckhausen, 1991; Olweus, 1977). Tolman (1952) suggests that by taking into account the particular context that the motivational process occurs, motivational levels may be "detected" by the examination of antecedent and consequent variables to that motivational process. Such an approach has been used in more recent research related to expectancy-value in motivation by Feather (1982), Heckhausen (1982), and Kuhl (1982), in that expectancy-value relationships are examined as preliminary to the formation of intentions and subsequent actions.

Expectancy-value theories alone, however, do not adequately address the formation of intentions beyond the prediction of those intentions (Heckhausen, 1991). Furthermore, expectancy-value theories often make the assumption that expectancies and values are fully integrated in an individual without examining underlying factors (Heckhausen, 1982). The selection and implementation of a particular behavior are manifested as intentions and subsequent actions. Therefore, the selection can be seen as a motivational process, while the subsequent action is the motivational effect..

Motivational processes for an individual are shaped by the sources of information an individual is comfortable with. Individuals that refer to external sources of information, such as personal status as compared to other individuals or tangible rewards, typically exhibit extrinsic motivation and can be said to be control-oriented (Deci & Ryan, 1987). Another term that can be applied with respect to extrinsic motivation is a consummatory (Deci & Ryan, 1987) motivational orientation. Internal referents facilitate autonomous behavior by individuals. Such motivational processes are said to be intrinsic, and reflect the nature of an individual's self (Deci & Ryan, 1987; 1991). Intrinsic motivational processes stem from a personal interest in the motivational object, whereby a task is undertaken purely for its own sake, generally in association with a positive affect toward expected outcomes. Intrinsic motivational processes are dependent on the extent to which an individual can be considered autonomous (Deci & Ryan, 1987; Ryan 1982), or subject to an internal locus of control.

Between the two extremes or motivational orientations are levels of extrinsic and intrinsic motivation that generally represent the extent to which the weight an individual attaches to the outcome is consistent with the values of the individual (Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan, 1982). A motivational orientation might be be termed instrumental to the extent to which the motivational orientation can be viewed more as a means to an end, such as by getting good grades or completing a project.

If motivation is considered as a context-specific cognitive process, using the models of Deci (1975), Deci & Ryan (1982, 1985, 1987, 1991) and Heckhausen (1991), motivation can be seen as related to a learner's social cognitive development (SCD) in that a learner's SCD provides a base for formulating interpretations of a given situation (Anderman & Maehr, 1994). Motivation as an explanatory concept has been used in the context of museum visitor studies before, but generally devoted to exhibit design (Falk, 1983) and only recently connected to learning in museum studies (Salmi, 1993). Most studies in informal science education (ISE) environments

have assumed that the motivation of adolescents to participate in a venue to be intrinsic e.g. for the sake of the experience, without considering motivation in the context of intention, action, and evaluation or any other specific theoretical framework. Adolescent motivation has been examined in individual ISE environments (Ernst & Young Management Consultants, 1990, 1991, 1992; Salmi, 1993), but not across several ISE environments. The theoretical frameworks of these studies are largely rooted in expectancy-value descriptions of motivation, without considering their context-specificity in an action-theoretical or developmental perspective and are limited in the inferences and generalizations that can be drawn from them.

Action

It is important to consider actions as distinct from behavior in general, as actions consist of those behaviors to which an individual attaches "meaning" (Weber, 1921). In order for such behavior to be called action, an observer must be able to discern the "meaning" or "reason" for such behavior (Heckhausen, 1991, p.12). Brandstädter (1984) furthers this definition of action by requiring that an action be a planned behavior that is (1) a means to attain certain goals or values, (2) was freely chosen on the basis of an individual's orientations, and (3) are explainable with respect to those orientations. Actions can thus be defined in terms of their antecedents, such as motivational processes, as well as their consequents, such as evaluations, but only to the extent to which such actions represent social cognitive developmental stages (Brandstädter, 1984). Antecedent-consequent relationships are not causal; rather, they provide structure for analyzing developmental stages within an individual. A dynamic action model is proposed by Atkinson & Birch (1970, 1974), wherein situation and person-specific variables are integrated within a framework of expectancy and value. Inclusion of situation-specific and individual-specific referents in an analysis of antecedent-causal relationships is essential if the goal of such an analysis is to show correspondence between intention and action. When carrying out a particular action, Kuhl (1983, 1984, 1987) assumes that several motivational conditions have been met by an individual, including selective attention, parsimonious information processing, and internal controls relative to encoding, emotion, and environmental cues. Given such control factors, the extent to which they are internalized by an individual and not imposed from outside reflects the degree to which a behavior is self-regulated.

Social Cognitive Development

When an action is more intrinsically motivated or self-determined in intention, greater cognitive effects are observed (Nicolopoulou, 1993), moving from more concrete external-rule base structures to more abstract, internal governance structures. Evaluations of actions can thus contribute to or shape social cognitive development (Enright, 1980) by defining an adolescent's personal self-image and relationship with the environment (Eckensberger & Meacham, 1984).

Social cognitive development (SCD) describes the context-specific process of growth in

cognitive abilities as a result of social interactions (Bradley, 1985; Brandstädter, 1984). Developmental levels are manifested in the extent to which an individual can verbalize responses to conceptual questions (Enright, 1980). The degree of "voice" that an individual is able to express in a particular context provides direct information of the developmental level. SCD is of particular interest in adolescents, as they begin to shift to from strictly concrete operations to using those concrete operations to form hypotheses about their own reality (Inhelder & Piaget, 1958). That SCD could be directly influenced by reflections on action should come as little surprise. When geared to the level of potential development of an individual, opportunities to learn have the effect of advancing actual cognitive development (Rogoff & Wertsch, 1984; Vygotsky, 1987). An individual's level of social cognitive development can provide information in the development of a particular motivational orientation or resultant motivational tendencies (Heckhausen, 1991). Subsequently, the evaluation of a motivation-action sequence is contributory to SCD. A complete hypothetical model for a motivation-action-SCD cycle is shown in Figure 1.

Insert Figure 1 About Here

Contexts of Science Education

The terms "nonformal" and "informal" tend to be used interchangeably (Maarschalk, 1988). Several distinctions can be made with respect to these and formal education. Formal education implies some plan of action and assessment in a recognized institution, such as a school (Maarschalk, 1988; Wellington, 1990). Nonformal education programs also have some plan involving curriculum or outcomes, but the execution is less rigid and the context is some non-traditional environment, such as a library or a museum (Crane, 1994; Flexer & Borun, 1984; Koran, Longino, & Schafer, 1983; Maarschalk, 1988). Informal education reflects a lack of set plans and a general atmosphere of spontaneity. This type of education can take place in a variety of settings, including both formal and nonformal settings. In fact, much of what is currently called informal science education is in fact nonformal, as there is some plan or curriculum in a non-traditional setting, as is apparent in the National Science Foundation (NSF) Informal Science Education funding summaries (NSF, 1991). In this study, it was assumed that adolescents participating in ISE activities were already motivated to do so.

For the purposes of this investigation, the term informal will be used with those venues that the either learner enters freely without specific learning intentions or plans, or those venues in which the learner enters with an objective in mind and the venue does not provide an agenda. In either case, the venues are located in non-school settings. Formal science education (FSE) will be used in the context of activities involving a specific learning plan on the part of the venue and learning intent on the part of the learner, situated in a traditional environment.

Methodology

As the purpose of this study is to determine the form and nature of early adolescent's motivational processes that lead to a freely chosen decision to engage in science learning activities, the research questions addressed by this study are aimed at outlining the cognitive framework in which such decisions are made. As the structures of ISE and FSE environments differ, the questions are necessarily general yet reflective of the sequence of events in this study:

1. What are the common denominators of (a) motivation, (b) action, and (c) social cognitive development in young adolescents within ISE venues?
2. What are the relationships between these common denominators in the facilitation of adolescent motivational processes to engage in science-related activities within ISE venues?
3. To what extent are the motivational factors inherent in ISE venues of use to FSE practioners in the middle grades?

Versions of the first two questions were presented in Pyle (1995), and are presented again to reflect the continuity of that study with the present one. With respect to Question 1, the term common denominators is used to define those elements of motivation, action, and SCD that were observable, emergent, and relevant across venues. The common denominators can be viewed metaphorically as those factors which "stuck to the web" in the course of data collection in Phase II, the "web" representing the greater ISE context. The common denominators were formative in the understanding of the relationships refered to in Question 2. Phases III & IV are specifically designed so as to detect those areas of convergence and thus answer Question 3.

Phase I - ISE Settings

A list of ISE venues was drawn up by consulting with several science education professionals with an interest in ISE, several middle grades students in the local area, and from reflections on past experiences with ISE. From the list generated, it was determined that three would be of particular interest to me, have the potential for yielding useful information, and have easy access to potential participants. They were science/technology centers (SciTrek - Atlanta, Discovery Place - Charlotte, National Science Center - Augusta), science-oriented stores (Nature Company Stores - Atlanta and Charlotte, Science Hobbies - Charlotte), and a hobby venue (Go-Kart races in Athens, GA, and Charlotte).

Phase II - Interviews and Observations

In this phase, participants were interviewed and videotaped or observed within the site. Videotaping was conducted unobtrusively from a distance. Participants included early adolescents (grades 4-8), their parents or responsible adults, and venue staff. Individuals from historically underrepresented groups were included, to the extent that they were available at each site. The interview protocol contained questions that address the motivational orientation, influences on action, and the social cognitive development of the participants. By getting participant responses within the specific context, the participants would not have had the opportunity to color his or her

reflections of the experience in the venue by the influences of another context (Nisbett & Wilson, 1977; Ross 1989), such as visits to other non-related sites or school. Interviews were conducted upon either entry or exit or both, at the circumstances allowed.

Phase III - Questionnaire Administration in ISE Locations

The assertions generated from analysis of the interview data and video tape evidence were used to develop a Phase III questionnaire. The questionnaire was designed to confirm or refute the assertions generated as a result of the Phase II data collection, and provide a baseline for comparison between ISE and FSE locations. The questionnaire was constructed as a series of vignettes that reflected situations where an adolescent could come into contact with a particular type of science content or science skill. After each vignette, adolescents were presented with a series of six statements and were asked to rate their level of agreement. The statements were based on the salient constructs derived from the assertions generated by analysis of the Phase II data, to include: (a) relationships with peers; (b) involvement by adults; (c) autonomy in decisions; (d) support of autonomy by adults; (e) personal competence in the situation; and (f) effectance with respect to outcomes. The questions were in a seven-point semantic differential format, with responses scored from (1) to (7). An sample vignette and associated questions is found in Figure 2. The Phase III questionnaire was administered to adolescents only as they entered one of the three museums used in Phase II, or as they exited two of the Nature Company stores (Charlotte, NC and Underground Atlanta). No kart races were used as part of Phase III as the kart racing season did not begin until after Phase III was completed.

Insert Figure 2 About Here

Phase IV - Identification of ISE and FSE Convergence

The final phase of data collection involved the determination of convergence, either potential or extant, between ISE and FSE. This phase involved the contacting of three middle grades science teachers that had developed or demonstrated instructional approaches in their home schools that parallel or match the salient constructs as identified in Phase II. One teacher, identified from her presentation at the 1995 Georgia Science Teachers Association (GSTA), was a 7th grade life science teacher at a middle school in southern Georgia. A second teacher, who teaches eighth grade earth science in the Atlanta area, was identified from a newspaper article in the Atlanta Journal-Constitution. The third teacher was identified serendipitously, through personal contact while supervising two preservice teachers in her eighth grade classroom. The teachers were interviewed with respect to their instructional approaches to ensure the appropriateness of their incorporation into this study. Once the teachers were included in the study, their students were asked to complete a questionnaire identical to the one developed for Phase III. Students were

also interviewed briefly to gain a general indication of the classroom environment with respect to the salient constructs, to both clarify responses to the questionnaire and to validate the inclusion of their class in the study. The results of Phase IV were compared to the data collected in Phase III. Any similarities between the two databases was judged to be an appropriate "bridge", or area of convergence, between ISE and FSE.

Instrument Validity

Instrument validity was a primary concern in the development of the Phase III/IV questionnaire.. Using expectancy-value instrumentation alone, it is possible to determine only a vague representation of an adolescent's expectancy and value with respect to science learning opportunities in general. Sullins and her colleagues (1995) attempted to adjust for the general nature of such questionnaires by changing the language of the questions to reflect the context in which the instrument was administered, in this case undergraduate science courses. Their adjustments did not account for specific, perhaps episodic contexts, but only the general context of a college science course. This study captures more of the situation-dependency of adolescent motivational processes by using discrete vignettes. Each vignette used in the instrument represented a context in which an adolescent would freely choose to engage or not, within the range of possibilities presented. The representation of discrete contexts allows for a closer approximation of an adolescent's motivation with respect to science closer than the more general, "I expect to do well in science this year" and "I like science". Further, the use of such vignettes immerses the adolescents in a hypothetical context, potentially diverting mischievous adolescent tendencies to attempt to "psyche-out" the instrument. Therefore, the use of vignettes enhances instrument validity.

As each type of response question can be directly related back to one of the salient constructs derived from the data analyzed in Phase II, validity has been reasonably established with respect to the content of each response questions. The content validation of each question was based on the observed and described behaviors (Cronbach & Meehl, 1955) of adolescents and contained language that was reflective of the construct being measured, firmly rooted in the constructs derived from the qualitative data.

As a final check of the validity of the instrument, several "content experts" were called upon to review the completed questionnaire. These "experts" consisted of middle school teachers, and adolescents and their parents. While the teachers believed that the questionnaire looked appropriate, the adolescents offered straightforward and clear comments as to the content of the vignettes and the structure of the questions. Parents of adolescents completing the questionnaire as a part of Phase III were asked to review and comment on the questionnaire. All accepted the final draft as appropriate.

The administration of the questionnaire in Phase IV was followed by asking the adolescents completing the questionnaire several follow-up questions regarding their teachers' instructional approach and classroom environment. This was done in order to: (1) further validate the

questionnaire with respect to the six constructs, and (2) validate the selection of the particular FSE environments. The adolescents consistently reported that their teachers supported their relatedness and autonomy in the course of instruction, while remaining involved in their learning. Further, the adolescents believed themselves to be competent in science and that they could effect changes in classroom outcomes that reflected their autonomy. These correlations of responses with self-reported behaviors within the classroom also serve to establish the validity of the questionnaire (Cronbach & Meehl, 1955). Thus, the selection of these teachers for inclusion in Phase IV was appropriate, and that the questionnaire did in fact measure the constructs that it was designed to measure.

Instrument Reliability

The reliability of the questionnaire was checked by determining consistency across vignettes (for each construct) and within vignettes (for each situation), by calculating Cronbach coefficients alpha (Cronbach, 1951). Across vignette consistency ranged from 0.61 for autonomy measures to 0.78 for competence. Within vignette consistency ranged from a low 0.64 for vignettes 1 and 4, to a high of 0.86 for vignette 8. Given the small number of items (6 questions x 8 vignettes) and the limited number of responses (n=143), such relatively low values are understandable, but offers promise for enhanced reliability with a larger pool of questions and respondents. Measures of internal consistency are found in Table 1. The relatively high values and the close similarity between the values seem to suggest that the questions are measuring different aspects of one generalized construct, which in this case would be adolescent motivational processes with respect to science learning opportunities.

Insert Table 1 About Here

Based on the two types of internal consistency information, the reliability of the instrument is fairly high, especially when considering the prototypical nature of the instrument. In addition, the somewhat "orthogonal" internal consistency (both across- and within-vignettes) supports the construct validity of the questionnaire (Cronbach & Meehl, 1955). With minor revisions and a larger pool of vignettes, the instrument will become even more reliable and allow further analyses within ISE and FSE environments.

Data Analysis

To capture the full picture, interpretive data analysis methods were required (Erickson, 1986), observing the informal learning process "in context" (Scribner & Cole, 1973; Mercer, 1992). A typological analysis was selected for Phase II, because it was useful to have the flexibility to describe phenomena as well as generate theories (Goetz & LeCompte, 1984). A typological analysis is also useful for analyzing data collected across research sites and adapted for

enummerative purposes. A typological analysis involves:

> dividing everything observed into groups or categories on the basis of some canon for disaggregating a whole phenomena. Such typologies may be devised from a theoretical framework or set of propositions or from common sense or mundane perceptions of reality. (Goetz & LeCompte, 1984, p.181)

The typologies used in the analysis of this study were developed from theoretical frameworks of: (1) motivation theory; (2) action theory; and (3) social cognitive development. Although the general typologies were determined a priori within a theoretical framework, they were of a nature general enough so as to minimize bias during analysis (P. Oldfather, personal communication, January 23, 1995). The individual codes used as a part of the analysis were emergent from the data and were categorized within the typologies defined above. The analysis was greatly facilitated by the use of the HyperRESEARCH software package, version 1.55, available from Researchware, Inc. Analysis of the data allowed me to develop salient constructs, or constructions that stood out from the data and were translatable into questionnaire items, that were used to guide the development of a Phase III/IV questionnaire.

Phase III and IV data were analyzed by first aggregating responses to each of the six question types for each questionnaire completed. Thus, each questionnaire received a total of six scores based upon the salient constructs outlined above. The Phase III and Phase IV scores were then compared the descriptive statistics of all six subscores between locations (ISE or FSE) with the potential for more inferential statistics. Analysis was facilitated by use of IBM-PC based Statistical Analysis System (PC-SAS), version 6.04. The hypothesis tested was that there would be no detectable difference between the ISE and FSE locations with respect to the six constructs represented by the subscores. The lack of significant difference with respect to either independent variable would signify convergence between ISE and FSE with respect to the construct being tested.

Results - Phase I/II

As was reported in Pyle (1995), interviews began during the summer of 1994, and were completed during the Fall of 1994. Groups typically encountered consisted of at least two adolescents and one adult, with some groups consisting of 4 students and two parents. As a result, I collected data from a total of 137 individuals (78 adolescents, 47 adults, 12 staff). What follows in this section is a brief review of those results.

Emergent from the collection of data in Phase II was the notion of connectedness between adolescent motivation, action, and social cognitive development. The model proposed in Figure 1 for a motivation-action-SCD cycle seemed to fit the observations that I had made quite well. It became apparent that the responses to the interview questions did not necessarily reflect the vertices of the motivation-action-SCD triad, but rather the linkages between the vertices.

The constructions resulting from the typological analysis are not the only ones possible from the data collected; far from it, they represent only those assertions that could be considered

most relevant to adolescent motivational processes in ISE environments. In brief, the constructions are: (1) activities by early adolescents appear to take place within social groups that mirror stages in the development of self-regulated behaviors, (2) although the principal motivational orientation appeared to be intrinsic, adolescents usually displayed a linked secondary motivational orientation, (3) evaluations by the adolescents of their experience within the venue seemed to be closely linked to the motivational processes that facilitated engagement in the venue, and (4) while adolescents in each venue seemed to go through similar types of motivational processes and actions, different venues seemed to facilitate different strands in a motivation-action-SCD cycle. Constructions (1)-(3) represent the "filters", or linkages between each vertex of the cycle, while construction (4) displays the unique character of each venue examined, embedded within the cycle.

Social Groupings and Learning

Learning activities by adolescents appeared to take place within social groups that mirror stages in the development of self-regulated behaviors. Adolescents learn how to self-regulate their actions within an ISE venue as a function of their social cognitive development. Students seem to gradually take on more cognitive control of their actions, listening to that "small still voice" (Belenky, Clinchy, Goldberger, & Tarule, 1986) that will guide their choice of activities while in their social groups.

It became apparent early in this study that participants and adult guides fell into one of four groupings, based on the level of (or lack of) social interaction. These categories are: (1) adult-as-guide, providing some level of informed instruction and/or guidance, (2) adult-as-co-learner, in which the participant and the adult shared a joint learning experience and alternated roles as instructor and learner, (3) peer learning, in which groups of 2-3 participants learned together and shared impressions, and (4) independent learning, in which the participant proceeded through the location without specific guidance or interaction with peers or adults. I first noticed these categories while I conducted the interviews, by noting the extent to which the adults or peers interacted while the questions were being asked. These same categories were also evident as I observed the participants within the venue, either directly or by videotaping. The categories were distinguished by the extent to which participants were able to "speak their mind", or use "voice" during the interview.

As I reviewed the interview transcripts, it was relatively easy to make an estimate of the adolescent's voice. For instance, adolescents that replied to interview questions with, "I don't know" or "I guess" were coded as lack of self voice. This assumption was triangulated by the parents' interjections or reinterpretations of my interview questions. The students did not solicit input from their parents: they "didn't know that they didn't know" how to answer. The adult acted as an instructional guide while within the venue.

In contrast, adolescent responses coded as voiced, but not strong typically exhibited some independent voice while answering the questions, but referred back to their parent for interpretations or cues as to the substance of their response. These adolescents "knew that they

didn't know" in that they perceived some gap between their capacity to respond and what I was asking of them. They knew, however, that there were some sources of information they could refer to, such as their parents or the venue itself. Further, there were indications that the parents felt that they could learn as well as their children from their visit to the venue. Adolescents and parents exhibiting these responses and subsequent actions were tagged as Adult-as-Co-Learner.

At the inception of this project, I assumed that I would interview parent-adolescent dyads. In fact, many of the groups that I was able to interview consisted of 1-2 adults and as many as 4-5 adolescents and younger children. While this initially presented a problem, it soon became apparent that it was an opportunity to observe peer learners in action within the venues. Responses to my questions were typically mirrored between adolescents within a peer group, even when the sequence of the adolescents being interviewed was varied. Typically, these adolescents did not individually refer back to their parents, but to each other in the course of their progress through the venue. Parents and staff members were able to corroborate this observation, citing either their joy at seeing such an occurance or their difficulty in approaching a peer group for instructive purposes. I would suggets that adolescents acting in peer groups each displayed some self-voice, but such voice was indistinguishable from the group voice.

Independent learners clearly possessed a self-voice by providing responses that were idiosyncratic and completely independent of parents or potential peer-learners. In fact, the independent learners seemed to deliberately distance their responses from others within the interview group. Little or no mediation of the interview questions was required by adolescents in this category. In fact, they were quite capable of providing a hypothetical science test question based on their knowledge base. These adolescents also "walked the walk", with actions in the venue being conducted independent of others. The independent learners have, it would seem, have mastered a degree of self-regulated behavior.

These categories of interactions parallel the instructional taxonomy proposed by Diaz and his colleagues (1990) for promoting self-regulated learning in children, by the development of domain-specific internal "voice". Their taxonomy, based on the work of Vygotsky (1960/1981) has in the first stage the adult regulating a child's behavior by controlling "concrete, immediate stimuli" (Diaz et al., 1990, p.133). In the second stage, the child begins to master those concrete stimuli, requiring less guidance by the adult guide. In the third stage, the child begins to regulate their own behavior, choosing particular courses of action within existing arrangements of external stimuli. In the final stage, a child is in complete control of his/her behavior, choosing instead an internal organization of external stimuli. In other words, a child progresses from an implicit expectation for instruction and guidance in a novel situation to self-guidance in those same situations.

Two constructs were useful in measuring the extent to which SCD affects motivational processes and can be seen as the linkage between SCD and motivation (refer to Figure 1). Representations of the voice that the adolescent attended to can be expressed in the extent to which the adolescent felt that others had a role in their motivational processes and subsequent actions. Specifically, adolescents could be said to attend to the involvement of adults or to their perceptions

of relatedness with peers in their cognitive process. These two constructs appear to be related but not mutually exclusive. Rather, they represent the extent to which the adolescents attended to clearly external referents as well as referents that were much more internal.

Coupled Motivation

Although the principal motivational orientation appears to be intrinsic, adolescents usually displayed a linked secondary motivational orientation. The secondary motivation was almost always reflective of an instrumental or consummatory orientation. The relationship between the primary (intrinsic) and the secondary (instrumental or consummatory) was determined by both the frequency of response and the order of response. For example, when asked why they visited a particular location, adolescents typically replied that the location was "fun" or "because its neat!" or that the location "had neat stuff". Further probing often, but not always, revealed that secondary motivations were also present, such as a need to use knowledge gained for a specific task (instrumental) or to secure some material benefit (consummatory).

With respect to the primary intrinsic motivational orientation, I could identify four general types of responses could be seen as representative of "intrinsicness". Responses that indicated (a) some sort of positive feeling, (b) an association with play, (c) an expectation of concrete stimuli, and (d) autonomy and personal decision-making on the part of the adolescent reflect the nature of the intrinsic motivational processes. These four categories lend substance to responses of "neat" and "fun". That the categories reflect intrinsic motivational processes are dependent on the degree to which they reflect the adolescent's "self" (Ryan, 1993). In order to classify an adolescent's engagement in an ISE venue as the effect of an intrinsic motivational process, I felt that the adolescent had to tell me or at least exhibit something that indicated their "self" in their actions. I was not disappointed in any venue, as even the students with the weakest self-voice were able to provide indication of one of points a-c above, as well as point d., autonomy. I believe that autonomy, the fourth dimension in the intrinsic motivational process, is perhaps the most important, in that the "authentic" self is represented (Deci & Ryan, 1991). In a sense, by representing "self", an action has the endorsement of the actor and represents a level of integration of the individual to the action (Ryan, 1993). Thus attestations or demonstrations of free choice by the adolescents Parents and staff members also provided information with respect to autonomy. In their case, however, autonomy support appeared to be most important.

I found that indications of intrinsic motivational processes in adolescents were particularly strong not in isolation, but rather as a springboard from which other motivational processes were derived. Specifically, intrinsic motivational effects were manifested as instrumental or consummatory motivational processes, each of which in turn had their own motivational effects. This linked motivation effect is particularly well displayed in the case of "Rat Basketball", in which staff members were encountered with three adolescent one Sunday. The adolescents said that they needed to see someone about rat basketball, "very badly". They were told to return on Monday, at which time they brought a rat in a shoebox. The staff members commented to them that the rat looked pretty bad, to which the adolescents replied, "Oh, he got pretty hot coming down here, so

we poured water on him." The adolescents were subsequently taught not only how to train their rat, but also how to properly care for him as well as general rat anatomy. The adolescents could be seen to operate first from an intrinsic motivational process, the motivational effect being their intention to return to the museum to train their rat to play basketball, which in itself is an instrumental motivational process. The term instrumental refers to a specific intention to use knowledge or experiences gained as a result of engaging in a particular action. In this sense, the motivational process is directed at an external action-object. To the extent that I could observe instrumental motivational processes, each occurred before actual engagement, during the adolescent's progress through the venue, or over an extended period of time.

Motivational processes linked to the intrinsic motivation process are not limited to utility or instrumentality of the action. They also include those motivational processes that involve some material or physical outcome as a goal object. Again, the intrinsic motivational process fills a primary role, setting the stage for a secondary consummatory motivational process. Intentions related to consummatory motivational processes, like those of instrumental motivational processes, can be formed prior to or during involvement in an ISE environment. The consummatory motivation is, however, a motivational effect of the intrinsic motivational process. Adolescents typically stated some material or extrinsic goal when asked why they engaged in a venue, such as "I want to get...". When questioned further, the consummatory motivation was not based on the intended action-object, but rather an intrinsic motivational process, such as "because I was interested in it." The intrinsic motivational process thus seems to form "meta-motivation" (Boekaerts, 1995), which guides subsequent motivational processes while simultaneously remaining active.

As each of the motivational processes that I found evidence for in this second construction had at least some element of intrinsicness, then measures of autonomy and autonomy support are useful in describing the linkages between motivation and action (refer to Figure 1). To the extent that intended actions by the adolescents are freely chosen and representative of their selves, then the motivational processes leading up to those intentions are intrinsic. These actions can be considered autonomous, as they hold personal meaning for the adolescents. But those same freely chosen actions would not have the opportunity to take place without the support of the adolescents' autonomy. The extent to which adolescents perceive that their autonomous actions are supported by adults is represented by autonomy support.

Evaluation and Motivational Cues

When I questioned the adolescents about their experience while within the venue, their evaluations seemed to be closely linked to the motivational processes that first prompted their engagement in the venue. For instance, intrinsic evaluations contained the elements outlined above as being indicative of intrinsic motivational processes, such as positive feelings, play, the hands-on nature of activities within the venue, and their own sense of free-choice and support in that choice. Instrumental evaluations contained both elements of intrinsic evaluations, as well as some satisfaction of being able to put to use their new-found knowledge (or disappointment at not

finding out what they wanted to). Consummatory evaluations also contained elements of intrinsic evaluations, but then turned to the material aspects of the venue, such as an item purchase, a race won, or an artifact produced by some apparatus.

Two main constructs seem to encompass much of the expressions of evaluation. The first of these is competence, in which the adolescent feels more fully capable now that they have successfully completed a particular action or set of actions. The second construct is effectance, in which the adolescent expressed some capacity to change a particular outcome or redirect their efforts and knowledge n a novel direction. Such attestations as were made by the adolescents were also corroborated by the observations of the parents and staff members. By demonstrating both competence and effectance, adolescents define their fundamental ownership of their choices and attributions (Au, Scheu, Kawakami, & Herman, 1990).

In determining the extent to which an adolescent believes him or herself to be competent and effective in a given context, I believe that evaluations on actions represented in the thrid construction serve as the linkage between action and SCD (refer to Figure 1). Two main constructs seem to encompass much of what was contained in the expressions of evaluation. The first of these is competence, in which the adolescents believed themselves more fully capable once they have successfully completed a particular action or set of actions. The second construct is effectance, in which the adolescents expressed a belief that they possessed some capacity to change a particular outcome or redirect their efforts and knowledge in a novel direction. As an adolescent comes to recognize competence and effectance in themselves in given situations, then their SCD is enhanced in the direction of self-regulation of their behavior across situations, whether familiar or novel.

Situation-Specificity

As a result of varying the order of venues where I collected the Phase II data, I was able to observe that while adolescents in each group seemed to go through the same types of motivational processes and actions, different venues seemed to facilitate different strands in a motivation-action-SCD cycle. Each venue could provide the adolescents with what Paris & Turner (1995) describe as choice, challenge, control, and collaboration. These dimensions serve to define situations that promote learning-directed motivational processes.

Adolescents and adults in science/technology centers represented the adult-as guide and adult-as-co-learner categories well, while representing the peer-learning and independent learner strands to a lesser extent. Intrinsic motivational processes dominated, while the intrinsic-consummatory strand was secondary, adolescents seeking something in the gift shop at some point during their visit. The intrinsic-instrumental strand was weakly represented in the science/technology centers. Subsequent evaluations underscore the evidence of motivational processes, with intrinsic evaluations dominating intrinsic-consummatory evaluations.

In the commercial venues, adults-as-guides were virtually unrepresented, while independent learners were particularly common. Indeed, many of these adolescent were missed in the interview process as their parents were not present to provide informed consent to participate.

Adults-as co-learners and peer-learners were also well represented, but to a lesser extent. As might be expected, the intrinsic-consummatory motivational process appeared common, but it did not overshadow to a large extent the intrinsic-instrumental and the purely intrinsic motivational processes. Again, evaluations were based on the motivational processes present, all three evaluation strands being represented.

In the case of the kart racers, adults served mainly as guides, helping the adolescents prepare closely for the races. Peer groups also participated, but under the close supervision of the adults present. In the competitive spirit of the venue, the intrinsic-consummatory motivational process seemed to dominate, while the intrinsic-instrumental process was secondary, only to the extent that any knowledge gained was directed at winning a race and could thus be considered consummatory. Purely intrinsic motivational processes in the adolescent were virtually non-existent. Evaluations were based on the simple meter of did such actions affect the outcome of a race.

Consideration of the context in which adolescents are engaged in motivational processes is would seem to be crucial to any analysis. Differing situations, depending on how novel or mundane they are to individual adolescents will elicit different motivational responses. In measuring such motivational responses over several specific science-related contexts, I believe it is possible to generate a much more accurate picture of what motivates an adolescent to engage in science than would be generated by general measures of expectancy and value with respect to science. Each such context depicted should represent situations where an adolescent would have the opportunity to perceive each of the salient constructs listed above.

Results - Phase III/IV

The populations sampled in Phases III and IV were roughly equivalent. Phase III respondents were 63.8% female/36.2% male, while Phase IV respondents were 59.4% female/40.6% male. With respect to ethnicity, 78.7% of Phase III and 68.7% of Phase IV respondents were Caucasian, while 14.9% of Phase III and 22.9% of Phase IV respondents were African American. Of the remainder, 4.3% of Phase III and 3.1% of Phase IV were of Asian descent.

Measures of central tendency, analyses of variance, and reliability checks were conducted using programs specially prepared for use with this study. As the central purpose of this study was to identify areas of convergence between ISE and FSE environments, the null hypothesis, {H_0: means between ISE and FSE for each salient construct are the same}, is of particular importance in recognizing such areas of convergence. Each of the six salient constructs was treated as separate areas of potential convergence. Rejection of the null hypothesis for any of the constructs would suggest that the construct was not an appropriate area of convergence.

Analysis of the data showed that no significant difference existed between the ISE and FSE groups with respect to all six salient constructs. Means ranged from 4.55 (on a 1 to 7 scale) for ISE-relatedness, compared to 4.83 for FSE-relatedness, to 5.26 for ISE-competence, compared to 5.04 for FSE-competence. Several two-way ANOVAs were conducted, each using venue type

(ISE or FSE) as one independent variable, and controlled for gender, grade level, and ethnicity. Again, there was no significant difference between ISE and FSE responses on the six main constructs. This lack of any significant difference is important in that it establishes convergence between ISE and FSE environments on the six constructs, suggesting that what is expected by the adolescents in the ISE environments is also found in the FSE environments that I administered the questionnaire in. The results are displayed in Table 2.

Insert Table 2 About Here

Discussion

Areas of ISE/FSE Convergence

Based on the consistency of responses between the ISE and FSE environments, I believe that it is possible for science teachers to construct an instructional environment that facilitates adolescent motivational processes. To the extent that the six constructs identified represent components of adolescent motivational processes, then these components, which are a part of the ISE environment, can also become components of the FSE environment. Since it is apparent that adolescents are motivated to engage in science learning activities outside of school, then a science teacher incorporating the same types of components within his or her classroom environment should facilitate adolescent motivational processes towards engagement in science learning. Boekaerts (1995) contends that focusing on already motivated students is an essentially biased starting point. I would respond by stating that this bias is useful to the extent that it controls this study for outside influences by concentrating only on those students that are motivated. What remains to be tested is if a science teacher does not incorporate elements of adolescent autonomy, relatedness, competence, and support in his or her instructional environment, are his or her students be less likely to motivated to engage in science learning activities in school? This invites a closer study of any science teacher's instructional evironment in terms of the six major constructs determined by this study to be integral to adolescent motivational processes.

Utility of Measurements of Adolescent Motivational Processes

As previously mentioned, expectancy-value models of motivational processes stop short of describing an individual's actions or subsequent evaluations of the outcomes of those actions. Instruments based on expectancy-value models alone are therefore limited to expectancy-value relationships of adolescents' general orientations with respect to science. I have attempted to go beyond such general measures by including both the antecedents, which include expectancies and values as well as intentions, and the consequents of adolescent motivational processes, which include the actions and subsequent evaluation on action. Each antecedent-consequent chain of events is embedded in a specific science-related context. I believe that the instrument that I developed for the purposes of this study is a valid measure of adolescent motivational processes in

that it is based on attestations that adolescents made while engaged in science learning activities outside of school. The utility of the instrument is further enhanced by the consistency of responses within and across contexts represented in the questionnaire. Thus, I feel that I can "measure" adolescent motivational processes with respect to science learning activities in general, but only to the extent that such measures carefully address all the components of those motivational processes and consider them within specific contexts. The salient constructs used to compare adolescents in the two contexts should be viewed as representing the relationships between SCD and motivation, action, and SCD. In many respects, I found excellent correspondence between my results and the motivational frameworks of Deci & Ryan (1991), Ryan (1993), and Atkinson & Birch (1974).

Opportunities for Further Development

Triangulation.

One of the limitations of this study is based within Phase IV. In selecting the three teachers and their students as participants, the assumption was made that these three teachers had established an instructional environment conducive to motivating their students to engage in science learning. What I have not collected, however, is data from adolescents whose teachers have created an environment that is amotivational with respect to science learning.

Having data collected using the questionnaire that I developed for Phases III & IV would allow me to determine if the pattern of convergence that I identified with respect to the six constructs is general for all adolescents or only those within ISE and motivational FSE environments. If, for example, adolescents in amotivational environments exhibit a distinctly lower pattern of responses to questionnaire items that adolescents in ISE and motivational FSE environments, then that would suggest that a teacher should attempt to promote the six constructs in his or her planning and instruction. Should students in amotivational FSE environments exhibit a pattern of responses similar to or higher than those in ISE and motivational FSE environments in spite of their classroom environment, then that would suggest that strong agreement with the six constructs would be general to all adolescents and not necessarily subject to manipulation by teachers. This eventuality would not preclude the possibility that teachers could create classroom environments that motivate students to engage in science learning activities. Rather, such teachers would perhaps be employing instructional strategies that are not accounted for by this study. This would invite a closer and longer term investigation of just what strategies are effective in increasing student motivation with respect to science.

Predictive Value of the Questionnaire.

Another opportunity to develop this study lies in determining the predictive value of the questionnaire. It would be useful, for example, to randomly select middle school classrooms and then administer the questionnaire to those adolescents. Classrooms in which the adolescents report strong agreement with the motivational constructs could then be directly compared with classrooms in which the adolescents report a weak agreement with the motivational constructs. I would be able to make direct contrasts in the instructional approaches and classroom environment developed

by each teacher, by either qualitative or other quantitative measures. This approach would only be valid if the constructs were subject to manipulation by the teachers and not general to all adolescents, as described in the previous section. Several administrations of equivalent forms could be used over the course of the school year to develop a longitudinal database. By including elements of both the situation and the cognitive processes involved (Paris & Turner, 1995), the instrument has the potential to be very useful in predicting motivation across contexts or individuals.

Experimental Manipulation of Motivational Constructs.

A third means to develop this project would be to determine which, if any, of the six motivational constructs could be manipulated by teachers in their classroom. Specifically, I would envision a quasi-experimental design, developed in cooperation with a teacher, in which the teacher would attempt to increase his or her students' motivation to engage in science by concentrating efforts on one motivational construct at a time. Different teachers could concentrate on particular constructs in their classrooms and the results with respect to student motivation could then be compared directly. Again, the validity of this approach rests on the extent to which each construct is manipulable by teachers within the confines of curriculum and school climate. To the extent that effective teachers manipulate their instructional environment in order to impress upon students at least a perception of autonomy, the level and persistence of motivation by adolescents might be determined (Paris & Turner, 1995).

Applications

In considering the outcomes of this project, I have found that there are specific applications within the domain of teacher education. Indeed, I have been able to incorporate into my student teaching supervision and methods course instruction suggestions that embody the six motivational constructs. For instance, it almost seems self-evident that cooperative learning should facilitate feelings of relatedness by adolescents in class. Studies by Hartup and his colleagues (1993) go further, suggesting that adolescent peer groups should consist of friends instead of acquaintances, as friends have developed better conflict-resolution strategies. I have gone on to suggest to the preservice teachers that I have worked with that they investigate promoting student autonomy, allowing their students some measure of choice in how and what science they learn. Jacobs & Ganzel (1993) have argued that investigations of what motivates adolescents to make decisions and what decisions they make are more significant than determining the capacity of adolescent to make decisions in the first place. Further, I have also suggested to preservice teachers to experiment with instructional strategies that promote student competence and effectance, such as role playing and modeling concepts. They have expressed a willingness to try such strategies in their own classrooms, but generally want more information about the approaches I have outlined above, such as grouping friends, allowing student choice, and examining adolescent evaluations of classroom experiences. An evaluation of their efforts or future student teachers that I work with would perhaps be enlightening.

Another application of the results of this study would be with inservice teachers. One approach would be to incorporate the motivational constructs into mentor teacher training programs. Mentor teachers would thus be able to work with other teachers in a more familiar relationship in promoting the motivational constructs. Conceivably, any science teacher could benefit in his or her teaching practice by facilitating his or her students' motivational processes with respect to science. A final aspect of working with inservice teachers would be to incorporate opportunities for teachers to practice examples of each construct as a part of any content-specific inservice. In this fashion, these teachers would be able to practice and experience what they would expect to promote in their own classroom.

Conclusions

Given the results of this study, it might be possible for a science teacher to respond in a knowledgeable fashion to an administrator, who might say to the teacher that he or she, "just had to motivate" the students. Each construct isolated and confirmed in this study offers a framework for planningand developing instructional environments. Students will come to learn that science in school need not be a threatening environment, but rather one in which they will willingly take part not because they were told to, but rather because they see such participation as part of who they are. Ideally, more of these adolescents would chose to become scientists and engineers because it is what they see themselves as. They might also choose to become science educators, either in the classroom or within ISE venues, and that science become, to paraphrase Featherstone (1992), part of the "ordinary" world and not part of the "heroic" world.

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References

Anderman, E. M., & Maehr, M. L. (1994). Motivation and schooling in the middle grades. Review of Educational Research, 64(2), 287-309.

Anderman, E. M., & Young, A. J. (1994). Motivation and strategy use in science: Individual differences and classroom effects. *Journal of Research in Science Teaching, (31)*8, 811-831.

Atkinson, J. W., & Birch, D. A. (1970). A dynamic theory of action. New York: Wiley.

Atkinson, J. W., & Birch, D. A. (1974). The dynamics of achievement-oriented activity. In J. W. Atkinson & J. O. Raynor (Eds.). Motivation and achievement (pp.217-325). Washington, D. C.: Winston.

Atkinson, J. W., & Birch, D. A. (1978). Introduction to motivation (2nd ed.). New York: Van Nostrand.

Au, K. H., Scheu, J. A., Kawakami, A. J., & Herman, P. A. (1990). Assessment and accountability in a whole language classroom. The Reading Teacher, 43, 574-578.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). Women's ways of knowing: The development of the self, voice, and mind. Basic Books.

Boekaerts, M. (1995). Self-regulated learning: Bridging the gap between metacognitive and metamotivation theories. Educational Psychologist, 30(4), 195-200.

Bradley, R. H. (1985). Social-cognitive development and toys. Topics in Early Childhood Special Education, 5(3), 11-30.

Brandstädter, J. (1984). Action development and development through action. In M. Chapman (Ed.), Intentional Action as a Paradigm for Developmental Psychology: A Symposium. Human Development, 27, 115-118.

Crane, V. (1994). Understanding the dynamics of informal learning. In V. Crane, M. Chen, S. Bitgood, B. Serrell, D. Thompson, H. Nicholson, F. Weiss, and P. Campbell. Informal science learning: What the research says about television, science museums, and community-based projects. Dedham, MA: Research Communications, Ltd.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. Psychometricks, 16, 297-334.

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. Psychological Bulletin, 52, 281-302.

Deci, E. L. (1975). Intrinsic Motivation. New York: Plenum.

Deci, E. L., and Ryan, R. M. (1982). Effects of performance standards on teaching styles: Behavior of controlling teachers. Journal of Educational Psychology, 74(6), 852-859.

Deci, E. L., and Ryan, R. M. (1985). The general causality orientations scale: Self determination in personality. Journal of Research in Personality, 19, 109-134.

Deci, E. L., and Ryan, R. M. (1987). The support of autonomy and the control of behavior. Journal of Personality and Social Psychology, 53(6), 1024-1037.

Deci, E. L., & Ryan, R. M. (1991). A motivational approach to self. In J. E. Jacobs (Ed.) 1990 Nebraska Symposium on Motivation, vol. 38. Lincoln, NE: University of Nebraska.

Deci, E. L., Vallerand, R. J., Pelletier, L. G., and Ryan, R. M. (1991). Motivation and education: The self-determination perspective. Educational Psychologist, 26(3-4), 325-346.

Diaz, R. M., Neal, C. J., & Amaya-Williams, M (1990). The social origins of self regulation. In L. C. Moll (Ed.) Vygotsky and education: Instructional implications and applications of sociohistorical psychology. Cambridge, U.K.: Cambridge University Press.

Eckensberger, L. H., & Meacham, J. A. (1984). The essentials of action theory: A framework for discussion. Human Development, 27, 166-172.

Enright, R. D. (1980). An integration of social cognitive development and cognitive processing: Educational applications. American Educational Research Journal, 17(1), 21-41.

Erickson, F. (1986). Qualitative research on teaching. In M. C. Wittrock (Ed.), Handbook for research on teaching (3rd ed.), (pp119-161); New York: Macmillan.

Ernst & Young Management Consultants (1990). Audience research consortium: Summary of the first year of research. Toronto, Canada: Author.

Ernst & Young Management Consultants (1991). Audience research consortium: Summary of the second year of research. Toronto, Canada: Author.

Ernst & Young Management Consultants (1992). Audience research consortium: Summary report. Toronto, Canada: Author.

Falk, J. H. (1983). Time and behavior as predictors of learning. Science Education, 67(2), 267-276.

Falk, J. H., Koran, J. J. Jr, & Dierking, L. (1986). The things of science: Assessing the learning potential of science museums. *Science Education, 70*(5), 503-508.

Flexer, B. K. & Borun, M. (1984). The impact of a class visit to a participatory science museum exhibit and a classroom science lesson. Journal of Research in Science Teaching, 21(9), 863-873.

Feather, N. T. (Ed.) (1982). Expectations and actions: Expectancy-value models in psychology (pp.125-162). Hillsdale, NJ: Earlbaum.

Featherstone, M. (1992). The heroic life and the everyday life; Theory, Culture & Society, 9, 159-182.

Goetz, J. P., and LeCompte, M. D. (1984). Ethnography and qualitative design in educational research. San Diego, CA: Academic Press.

Haladyna, T., & Shaughnessy, J. (1982). Attitudes toward science: A quantitative synthesis. *Science Education, 66*, 547-563.

Hartup, W. W., French, D. C., Laursen, B., & Johnston, M. K. (1993). Conflict and friendship relations in middle childhood: Behavior in a closed-field situation. Child Development, 64(2), 445-454.

Heckhausen, H. (1982). Models of motivation: Progressive unfolding and unremediated deficiencies. In W. Hacker, W. Volpert, & M. v. Cranach (Eds.), Cognitive and motivational aspects of action (pp. 9-16). Berlin: VEB Deutscher Verlag der Wissenschaften.

Heckhausen, H. (1991). Motivation and Action. P. Leppmann (trnsltr). Berlin: Springer-Verlag.

Inhelder, B., & Piaget, J. (1958). The growth of logical thinking: From childhood to adolescence. New York: Basic Books.

Jacobs, J. E., & Ganzel, A. K. (1993). Decision-making in adolescence: Are we asking the wrong question?. In M. L. Maher & P.L. Pintrich (1993) Advances in Motivation and Achievement, Volume 8: Motivation and Adolescent Development, 1-31. London: JAI Press.

Koran, J. J. Jr., Longino, S. J., & Schafer, L. D. (1983). A framework for conceptualizing research in natural history museums and science centers. Journal of Research in Science Teaching, 20(4), 325-339.

Kuhl, J. (1982). The expectancy-value approach in the theory of social motivation. In N. T. Feather (Ed.), Expectations and actions: Expectancy-value models in psychology (pp.125-162). Hillsdale, NJ: Earlbaum.

Kuhl, J. (1983). Motivation, Konflikt, und Handlungkontrolle. Berlin: Springer-Verlag.

Kuhl, J. (1984). Motivational aspects of achievement motivation and learned helplessness: Toward a comprehensive theory of action control. In B. A. Maher & W. B. Maher (Eds.), Progress in Experimental Personality Research (Vol. 13, pp. 99-171). New York: Academic Press.

Kuhl, J. (1987). Action control: the maintenance of motivational states. In F. Halisch & J. Kuhl (Eds.), Motivation, intention, and volition (pp. 279-291). Berlin: Springer-Verlag.

Maarschalk, J. (1988). Scientific literacy and informal science teaching. Journal of Research in Science Teaching, 25(2), 135-146.

Mercer, N. (1992). Culture, context, and the construction of knowledge in the classroom. In P. Light & G. Butterworth (Eds.) Context and Cognition: Ways of Learning and Knowing (pp. 28-46).

National Science Foundation (1991). Summary of funded projects in informal science education, 1987-91. Washington, D. C.: Author.

Nicolopoulou, A. (1993). Play, cognitive development, and the social world: Piaget, Vygotsky, and beyond. Human Development, 36, 1-23.

Nisbett, R. E.& Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. Psychological Review, 84(3), 231-257.

Olweus, D. (1977). A critical analysis of the "modern" interactionist position. In D. Magnussen & N. S. Endler (Eds.), Personality at the cross-roads: Current issues in interactional psychology. Hillsdale, NJ: Earlbaum.

Pascarella, E. T., Walberg, H. J., Junker, L. K., & Haertel, G. D. (1981). Continuingmotivation in science for early and late adolescents. American Educational Research Journal, 18(4), 439-452.

Paris, S. G., & Turner, J. C. (1995). Situated motivation. In P. Pintrich (Ed.) Student Motivation and Cognition (pp. 213-237). Manwah, NJ: Lawrence Earlbaum Associates.

Pyle, E. J. (1995). Motivation and social cognitive development in informal science education venues: A developmental study. Paper presented at the 68th Annual Meeting of the *National Association for Research in Science Teaching*, San Francisco, CA.

Richardson, L. D. (1994). Sense-making in educational environments. Unpublished dissertation, University of Georgia.

Rogoff, B., and Wertsch, J. V. (1984). Editors' notes. In B. Rogoff & J. V. Wertsch (Eds.). Children's learning in the zone of proximal development. San Franscisco: Jossey-Bass.

Ross, M. (1989). Relation of implicit theories to the construction of personal histories. Psychological Review, 96(2), 341-357.

Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. Journal of Personality and Social Psychology, 43, 450-461.

Ryan, R. M. (1993). Agency and organization: Intrinsic motivation, autonomy, and the self in psychological development. In R. Dienstbier (Ed.). 1992 Nebraska Symposium on Motivation, vol 40. Lincoln, NE: University of Nebraska Press.

Salmi, H. (1993). Science centre education: Motivation and learning in informal education. Research Report 119, Department of Teacher Education, University of Helsinki.

Scribner, S., and Cole, M. (1973). Cognitive consequences of formal and informal education. Science, 182, 553-559.

Sullins, E. S., Hernandez, D., Fuller, C., & Tashiro, J. S. (1995). Predicting who will major in a science discipline: Expectancy-value theory as part of an ecological model for studying academic communities. Journal of Research in Science Teaching, 32(1), 99-119.

Tolman, E. C. (1952). A cognition motivation model. Psychological Review, 59, 389 400.

Vygotsky, L. S. (1960/1981). The genesis of higher mental functions. In J. V. Wertsch (Ed. & Trans.), The concept of activity in Soviet psychology. (144-188). New York: Sharpe. (Reprinted from Razvitie vysshikh psikhicheskikh funktsii, 1960, 182-223).

Vygotsky, L. S. (1987). The collected works of L. S. Vygotsky: Volume 1: Problems of general psychology (including the volume 'Thinking and speech'). R. W. Rieber and A. S. Cartan (Eds.) N. Minick (Trans.). New York: Plenum Press.

Weber, M. (1921). III. Abteilung. Wirtschaft und Gesellschaft. I. Die Wirtschaft und die gesellschaftlichen Ordnungen und Mächte. Grundriß der Sozialökonomik. Tubingen: Mohr-Siebeck (Reprint 1964).

Wellington, J. (1990). Formal and informal learning in science: The role of interactive science centers. Physics Education, 25, 247-252.

Table 1

Measures of internal consistency across and within vignettes.

	Across vignettes	Within vignettes	
construct	coefficient alpha	vignette	coefficient alpha
relatedness	0.64	1	0.64
involvement	0.63	2	0.72
autonomy	0.61	3	0.73
autonomy support	0.64	4	0.64
competence	0.78	5	0.77
effectance	0.73	6	0.77
		7	0.74
		8	0.86

Table 2

Descriptive statistics of Phase III and Phase IV questionnaire administrations

	ISE[a]			FSE[b]		
Construct	n	M	SD	n	M	SD
relatedness	45	4.55	0.97	91	4.83	0.98
involvement	45	4.88	1.07	94	4.78	0.98
autonomy	45	5.07	1.17	93	5.00	1.06
autonomy support	45	5.14	0.95	93	5.05	1.07
competence	46	5.26	1.23	93	5.04	1.22
effectance	46	5.21	1.17	95	5.02	1.13

[a]means taken across 5 venues. [b]means taken across three classrooms.

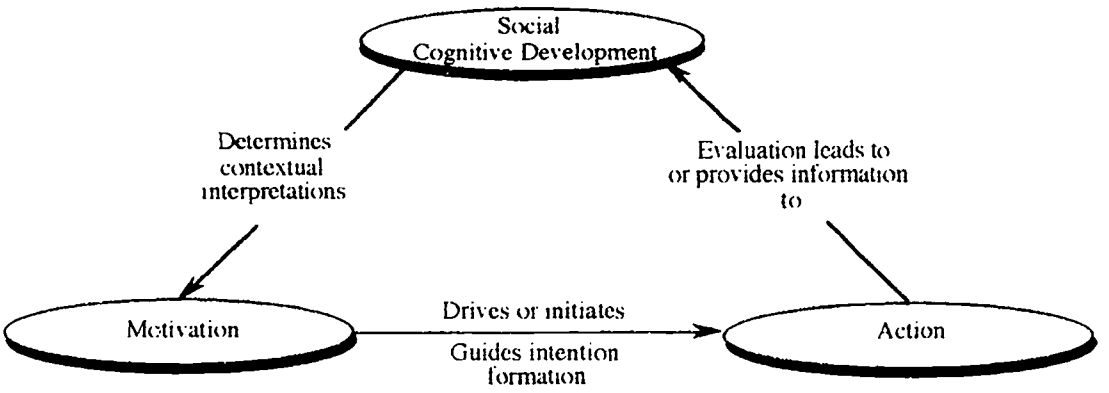

Figure 2 A model for a motivation-action-SCD cycle.

Figure 2. Sample item from Phase III/IV questionnaire.

5. While flipping through the channels on TV one saturday morning, you happened to stop at "Bill Nye the Science Guy". He's doing some strange experiments with a flashlight. After a few seconds, you decide to watch some more and put down the remote.

1. I can explain what is happening on the show to my little sister.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
never	almost never	a few times	sometimes	most of the time	almost always	always

2. My mom sits down to watch the show with me and asks me questions about it

(a)	(b)	(c)	(d)	(e)	(f)	(g)
never	almost never	a few times	sometimes	most of the time	almost always	always

3. I will keep watching the show because I'm interested in the experiments, even though the guy on the show is kind of dorkey.

unlikely	(a)	(b)	(c)	(d)	(e)	(f)	(g)	likely
	very	mildly	slightly	neither	slightly	mildly	very	

4. My parents would tell me they're glad that I chose to watch that show instead of some cartoon.

unlikely	(a)	(b)	(c)	(d)	(e)	(f)	(g)	likely
	very	mildly	slightly	neither	slightly	mildly	very	

5. I think that I can do the some of same experiments myself now.

untrue of me	(a)	(b)	(c)	(d)	(e)	(f)	(g)	true of me
	very	mildly	slightly	neither	slightly	mildly	very	

6. I can do better at science because I now know more about it.

untrue of me	(a)	(b)	(c)	(d)	(e)	(f)	(g)	true of me
	very	mildly	slightly	neither	slightly	mildly	very	