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TOWARD AN ECOLOGICAL RISK ASSESSMENT FRAMEWORK FOR SPECIAL EDUCATION

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We suggest a new framework for conducting research in the field of special education. This framework is inspired by the ecological risk assessment frameworks of the U.S. Environmental Protection Agency (1995) and G.W. Suter (1993), which are primarily used in ecotoxicology and environmental toxicology. The framework includes three phases by which an ecological risk assessment can be performed: problem formulation, measurement, and risk characterization. By outlining each of its phases, this article defines, illustrates, and explains the possible applications of an ecological risk assessment framework to the field of special education. For practical reasons, we provide an example of this first application based on persons with intellectual disabilities.

Since the 1970's, an ecological approach has influenced the field of special education as well as psychology, inspiring research and interventions. The application of an ecological approach to the social sciences has given rise to specific fields, such as: behavioural ecology or ecological psychology, also known as the School of Palo Alto, initiated by Barker's work in the 1950's; ecology of human development, inspired by Bronfenbrenner's work since the 1970's; social ecology, entailing a fusion of the aforementioned two fields; and educational ecology, as conceptualized by Legendre's work (Trepanier, 1999).

In essence, an ecological approach to special education emphasizes the importance of understanding the surrounding conditions (including people and their interaction with the child in a learning environment. At first glance, it seems that the use of an ecological approach in special education research and intervention is straight-forward and well documented. However, there is a need for further clarification of the concepts, theory, and methodology behind the approach. For example, the definition of the term ecology is not clear, as it can have many meanings. It is sometimes used as a synonym for the word environment, as illustrated in the 1986 study by Algozzine, Morsink and Algozzine. Alternatively, ecology can be used in reference to specific environmental variables, as seen in Rogers-Warren and Wedel's (1980) work. In special education (Algozzine et al., 1986; Rogers-Warren & Wedel, 1980; Nevin & Thousand, 1987; Sirotnik, 1984) the term *Classroom Ecology* is often used, but again without a clear operational definition. For instance, researchers in human ecology such as Bronfenbrenner (1993), Wachs (1991a, b) or Sroufe and Egeland (1991) define the process of interaction in different ways. Moreover, interaction is sometimes defined as a process and a process as an interaction, making it difficult to distinguish one from the other (Trepanier, 1999).

Numerous researchers in human ecology agree that studies using an ecological approach in social sciences do not look at the different levels of the ecosystem without ever considering the interaction process (Apter, 1977; Ballard, 1986; Beckwith, 1984; Bronfenbrenner, 1993, 1996; Delandsheere, 1986; Fraser & Fisher, 1983; McCall, 1991; Rutter & Pickles, 1991; Salomon, 1992; Wachs, 1991a; Willems, 1977). In addition, from a methodological point of view, studies using an ecological perspective in social sciences do not rigorously select variables or gather data or analysis (McCall, 1991; Rutter & Pickles, 1991; Trepanier, 1999; Wachs, 1991a, b). As long as these factors are not taken into consideration and only a partial application of the ecological model is pursued, its effectiveness and value as a model for human behavior development remains questionable. This observation is made by major researchers. (Bronfenbrenner, 1993; Bronfenbrenner & Ceci, 1993; Cronbach, 1991; Efron *in* Cronbach, 1991; McCall, 1991; Plomin & Hershberger, 1991; Rutter & Pickles, 1991; Wachs, 1991a,b).

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In this paper, we illustrate the application of an ecological risk assessment framework (ERA) similar to those used in ecotoxicology to develop risk analysis and/or risk management. To do so, it has to be kept in mind that the first goal in ecotoxicology is to identify, quantify, and ideally control the impact of pollutants (Plomin & Hershberger, 1991). The term pollution referring to the action of inhibiting factors in a particular environment (Holl & Cairns, 1995; Odum, 1971; Suter, 1993), which can be translated into inhibiting factors in educational and social environments such as a learning barrier.

The framework we propose here has its roots in risk assessment or risk analysis models, as used in fields like ecotoxicology, environmental toxicology, and environmental engineering (Cairns, 1995; Cairns & Niederlehner, 1995; Calabrese & Baldwin, 1993; Forbes & Forbes, 1994; Holl & Cairns, 1995; Krebs, 1989; Landis & Yu, 1995; Norton & al., 1995; Osenberg & Schmitt, 1996; Stewart-Oaten, 1996; Suter, 1993; Suter & Barnthouse, 1993). The methodology used to develop the framework is called *anasynthesis*, as proposed by Silvern in 1972 and further adapted by Legendre in 1988. The methodology entails an iterative process comprising of analysis, synthesis, prototype, and simulation steps, leading to the proposition of a model. In this paper, we propose an ecological risk assessment model for researchers in social sciences and as illustrated in Figure 1. In the remainder of the article, I will describe the phases and components of the framework.

An ecological risk assessment framework for special education

The ecological risk assessment framework for special education entails three phases: 1) the problem formulation, 2) the measurement, and 3) the risk characterization. Inspired by definitions used in ecotoxicology studies (Calabrese & Baldwin, 1993; CEAEQ, 1998; Forbes & Forbes, 1994; Norton & al., 1995; Osenberg & Schmitt, 1996; Suter, 1993 USEPA, 1995) we propose to define an *ecological risk assessment in special education* as an iterative process of studying ecologically adverse effects within person-environment ecosystems which then offers a way to define, quantify, and identify their acceptability. A person-environment ecosystem is a functional unit that entails the delimitation of the settings where a person or a group of individuals participates and interacts.

Since *risk* is a statistical concept, it can be defined as the probability of the occurrence of adverse ecological effects caused by a stressor on the person-environment ecosystem's dynamic. In other words, it is the probability of an adverse effect's action of a stressor on the person-environment ecosystem's dynamic.

As in ecotoxicology, where research provides foundations for risk evaluation and for decision making (Forbes & Forbes, 1994), we believe an ecological risk assessment framework will enlighten the process of risk management in special education, since it brings together the perspectives of the managers, politicians, and scientists.
Thus, a set of parallel activities can take place before, during, and after the risk assessment process. Some of those activities can also serve as input for the risk assessment process such as research program orientations, data acquisition, verification and monitoring, variables that will be explained next.

Research program orientations
Research program orientations are about setting up goals and an organized plan. That is, the managers and assessors discuss research planning and organisation to establish a research program that will consider the scientific as well as the political and social goals of the studies being led. The research planning process allows managers and scientists to explicitly discuss their expectations and goals for the studies to be conducted, and to coordinate their efforts. Cronbach (1991) suggests that step also for human ecology.

Data acquisition, verification and monitoring
Even though data acquisition, verification, and monitoring are part of the ecological risk assessment process, some studies may require additional and unplanned data gathering, which must also be linked to the risk assessment and risk management processes. Some verification studies make possible the validation of the risk characterization issued from the risk assessment. They can also offer ideas for improvement or new orientations for further studies. Finally, monitoring studies lead to a better understanding of a person-environment ecosystem, including an understanding of its optimal or acceptable conditions. The data gathered through such studies may also serve as input for additional risk assessment examinations. Renowned researchers in human ecology (Bronfenbrenner or Cronbach) emphasize the importance of collecting additional data. More specifically, Bronfenbrenner strongly recommends the inclusion of the contextual and non-contextual evaluations of the cognitive and socio-emotional functions of the study participants when designing ecological studies (Bronfenbrenner, 1996).

Phase 1: Problem formulation
Formulation of the problem should be the first phase of an ecological risk assessment framework in special education. This is the process of systematic planning of the study where the associated scientific, social, and political views are taken into account. This phase is the first step toward a better understanding of the interactions between a person and their environment. As proposed by researchers in human ecology (Bronfenbrenner, 1993; Cronbach, 1991; McCall, 1991; Wachs, 1991a) we also encourage a research design or research program that forces clarification of the object under study. There are three steps to the problem formulation phase:

1) identification and characterization of the person-environment ecosystem;
2) development of an exposure scenario;
3) endpoint selection.

Stage 1: Identification and characterization of the person-environment ecosystem
Generally speaking, an *ecosystem* consists of specified interacting units of the defined environment under study. Besides the person's characteristics, the environment must be delimited and specified. Here, we can define the *environment* as the setting composed of physical,

chemical, climatic, biological, cultural, and social units interacting with human beings. An ecological risk assessment also implies the accurate detailing of at least one stressor and its ecological effects. A *stressor* can be defined as a damaging factor for a part or the whole ecosystem - it has an impeding, harmful, or negative impact. Therefore, a stressor has an adverse effect on the ecosystem's dynamic. Other features of stressors in a person-environment ecosystem might be nature (physical, chemical, biological or social), intensity (concentration, dose or magnitude), length, occurrence, timing, and spatial extent. Ultimately, the origins of a stressor (analogously corresponding to Suter's source terms) must be considered with their direct or indirect and usual or unusual occurrence regarding its emission within the ecosystem under study.

To illustrate our idea, here is an example in the field of special education involving mentally retarded individuals, where a known stressor might be a complex task (the nature) that a teacher expects a student to undertake. The intensity could correspond to a level established through a specific observation checklist scale. The length should correspond to a temporal scale that is difficult to apply here, unless we fix it through the duration of a given intervention. The occurrence could refer to a number of observed intervention situations, for example. The timing, which is the moment when the stressor takes action, could also be set regarding a series of observed intervention situations. The spatial extent criterion could represent the inability to achieve a precise task in different settings. Moreover, the stressor can come from the teacher's planning (origin). Finally, the stressor's emission should be defined prior to the study, meaning that the complexity of a task can be direct or indirect, usual or unusual in given intervention sequences. For example, the complexity of a task could come from a verbal instruction from the teacher, which could be defined as a direct and usual emission.

The exposure of an individual(s) to a stressor should help define the negative or inhibiting impact of this stressor or its ecological effect. This exposure is another way to talk about the interaction between a stressor and an individual. An exposure to a stressor can vary in duration (instantaneous, irregular, short, or continuous) and intensity. For example, an exposure can be brief but intense. In this view, an *ecological effect* is the result of the exposure of individual(s) to a stressor. The exposure to the stressor results in a harmful impact on an ecosystem's state, dynamic or any of its components. Ecological effects can be direct or indirect. In the latter we could say that some ecological effects have an indirect influence when they are not acting on the core subjects of the environment or when their impact goes beyond the immediate environment's resources.

To follow our previous example involving mentally retarded individuals, the student's learning failure corresponds to a direct ecological effect. Indirect ecological effects that concern supporting elements or external environmental resources could be the teacher or peers' beliefs and perceptions of mentally retarded individuals and/or the perceptions of the school principal or the school board managers. The indirect ecological effects could also refer to the student's lower self-esteem and/or the teacher's preconception about the student's mental retardation and ability to learn.

Stage 2: Development of an exposure scenario

Following identification and characterization of the person-environment ecosystem, a qualitative description of the exposure to a stressor must be performed. Since the stressors are the pollutants of an ecosystem, this step calls for the researcher to hypothesize about the ways an exposure can occur in the previous delimited setting, taking into account the stressors' characteristics or actions on a space-time scale. Although this particular procedure has not been proposed by researchers using an ecological approach, some like Wachs, Bronfenbrenner or Rutter & Pickles do recommend hypothesizing about the ways a person and an environment may interact. For educational intervention, a number of exposure scenarios could be developed in order to attain the endpoints necessary to proceed with a risk analysis.

The following is an example of an exposure scenario that could be designed for a special education ecological risk assessment involving mentally retarded students, where the complexity of the task corresponds to the stressor. Here, we imagine a situation where a mentally disabled youth is settled for a school-work transition, and is asked to mop the floor in a restaurant. This task could qualify as an average complexity or intensity task, considering the sub-tasks it entails and the ease with which the learner manages it. The student's learning failure in this particular setting stands for not adequately fulfilling the task in that the learner take too much time to complete it (length) since he is unable to manage his time without guidance(timing). The failure to accomplish the task refers to the ecological effect according to our model. Indirect effects could be the negative perception of the employer about mentally retarded employees and/or co-workers overprotecting the youth by completing a part of the task. The source of such indirect effects could be traced back to the planning and the teaching process, or more specifically the instructions given by the teacher.

Stage 3: Endpoint selection

This last stage of the problem formulation phase allows us to specify what will be measured in the exposure scenario. In an ecological risk assessment, the classification units used to delimit and assess specific elements within an ecosystem are called *endpoints* (Cairns & Niederlehner, 1995; Norton & al., 1995; Suter & Barnthouse, 1993; US EPA, 1995). Hence, an endpoint is an ecosystem's characteristic that results from exposure to a stressor. Two types of endpoints need to be identified. First, the *assessment endpoints* refer to some specific elements that put the ecosystem *at risk* and which we wish to protect for in order to avoid exposure to a potential stressor. In the social sciences, assessment endpoints must refer to the characteristics of one or more individual or a group of individuals part of the ecosystem. For example, the cognitive development of a person could be an assessment endpoint. The second type of endpoints are measurable responses to a stressor related to the chosen assessment endpoints; they are called *measurement endpoints***.** In fact, measurement endpoints are formal quantitative expressions of a response or the result of an assessed exposure to a stressor. Following our example such would refer to the cognitive developmental stage of the person.

In the field of ecological risk assessment, Suter and Barnthouse (1991) identified five criteria of an endpoint whilst Cairns and Niederlehner (1995) identified 16 criteria, based on the work of major researchers like Suter (1990), Macek, Birge, Mayer, Buikema and Maki, (1978), Kelly and Harwell (1989), and Hunsaker and Carpenter (1990). When adapted to special education, we suggest the use of eight criteria for the selection of endpoints in an ecological risk assessment. The first criterion concerns the social and ecological *relevance*. Social relevance is important because selected endpoints must reflect social values and political goals. Ecological relevance is important in that it amounts to the key characteristics of a given ecosystem which are also interrelated. Secondly, an endpoint must be measurable implying an operational definition. *Efficiency or cost-effectiveness* is the third selection criterion for an endpoint. Each selected endpoint should allow for maximum collection of data at minimum cost. The *timely* criterion ensures that the selected endpoints give information about any *hazards* at the origin of the program while they also provide the necessary information for the best possible management action. Selected endpoints also need to be *interpretable*, such that distinctions between scientifically and/or legally acceptable conditions and unacceptable conditions can be made. Anticipation is another criterion of chosen endpoints; entailing the detection of degradation before it becomes too serious or advanced. Ideally, selected endpoints should be transferable to different study contexts for measurement continuity. Finally, a specific endpoint selection criterion refers to its sensitivity to a polluting exposure (i.e. a sensitivity to a stressor exposure) which is why endpoints are chosen directly from the exposure scenario designed in the previous stage. The endpoint selection must take into account the potential impact of the precise setting of the research problem.

Phase 2: Measurement

The second phase of an ecological risk assessment in special education consists of an assessment stage and a data processing stage, both based on the exposure scenario and the selected endpoints. The measurement phase entails the process of estimating the probability and the magnitude of the ecological effects. Since this phase, when applied to special education can imply specific statistical considerations, we will limit our proposal effort to a discussion of the general kinds of considerations to be taken into account without specific treatment of the statistics implied while recognizing their importance in an actual adaptation.

Stage 1: Exposure and effects assessment

The first stage of the measurement phase implies an assessment of the exposure and the ecological effects. This stage is about the quantification of the exposure, which is the contact, the co-occurrence or the interaction between four elements: a stressor, an individual (or a group of individuals), some components of the ecosystem, and the ecological effects of a stressor. The goal of the exposure quantification process is to assess the interaction between a stressor and other components of an ecosystem. Consequently, exposure quantification should involve an estimate of the stressor's intensity and length. It should also include an estimate of the stressor's occurrence, time sequence, route of exposure and dispersion, as well as its source terms and contact with the exposed individual(s).

Quantification of a stressor's ecological effect corresponds to the quantification of the interaction between a stressor and an assessment endpoint, or the quantification of adverse effects from a stressor. In an ecological risk assessment, quantification of a stressor's ecological effect is fulfilled by the specification of assessment endpoint and measurement endpoint (Suter, 1993a). When transferred to special education, the endpoint assessment entails the quantitative expression of each endpoint (or selected variables) that is susceptible to be negatively affected by a stressor. Accordingly, the endpoint measurement is the formal quantitative result of a test or measurement device that was used to evaluate the exposure to a stressor. In order to select the right instrumentation one should:

1) define precise questions that each chosen test will answer;
2) identify statistical considerations to be taken into account for each measurement device; and
3) consider the cost related to the test and data processing.

Stage 2: Data Processing

In the data processing stage it is presumed that the collected data will be processed through statistical methods and by mathematical modeling designed to relate and extrapolate measurement and assessment endpoints. In addition, such kinds of analysis will facilitate the description of the interacting magnitude, the occurrence, the length or the spatiotemporal patterns of exposure. At this level a statistician's expertise is essential to inform the researcher of the feasibility and the limitations of possible data processing techniques, and to help with the identification of required data codification. The statistician's awareness of hypothesis testing, statistical power, and error margins will also be helpful to the researcher when interpreting the research results.

As in the ecological risk assessment framework proposed by Suter (1993) we believe a scoring system would allow for the development of a hazard scale, to help classify the studied settings. Regarding the stressors' ecological effects, a number of scoring systems could be developed and used to classify the research settings. In an ecological risk assessment, risk is the probability of an actual action due to the effects of stressors. During the data processing stage, uncertainties deriving from the gaps or missing data must be considered as well. In fact, endpoint selection always implies a certain level of uncertainty which needs to be accounted for.
As explained by Suter (1993), uncertainties applied to an exposure or the concentration effect of a stressor can be used to correct a known source of uncertainty. Those uncertainties correspond to the ratio between two measurement endpoints. Keeping with Kuiper-Goodman's explanations (1989 *in* Forbes & Forbes, 1994), we believe the size of uncertainties depends on intra- or inter-individual differences in responses to a stressor, the adequacy of the collected data, and the stressors' characteristics. Hence, the identification of uncertainties during the measurement phase allows for the determination of the safety factors that will be needed for the third phase extrapolations. Those uncertainties will be essential to the decision makers and the managers to support their decisions and actions.

The data processing stage ends with a conclusion profile, designed to present the type of data processing used in the study, the results, and the uncertainties in the measurement. The conclusion profile is intended to sum up the amplitude, the spatiotemporal patterns of exposure, and the combination of the analysis of an exposure with the data related to the ecological effects. The data of the conclusion profile entails the effects of stressors in relation to the measurement endpoints. Analogously to US EPA types of interrelations, between endpoints in a stressor-response profile, six elements make up a conclusion profile of an ecological risk assessment in the social sciences:

1) interrelations between the data related to a stressor's response;
2) interrelations between two measurement endpoints;
3) extrapolations from one setting to another;
4) indirect effects analysis;
5) spatiotemporal scale analysis; and
6) ecosystem recovery.

Phase 3: Risk characterization

The third phase of an ecological risk assessment framework in special education consists of the risk characterization. It entails the integration of the measurement phase results. The risk characterization phase is intended to describe and estimate risk, and estimate safe exposure levels for managers and political decision makers, the general public, and other tenants. The risk description needs to take into account the selected endpoints from the problem formulation phase. As shown above, the second phase requires the expertise of statisticians, and/or ecotoxicological risk assessors, and/or ecological risk assessors. Since the third phase follows the output of the second, we will limit our proposal to basic recommendations. Adapted from the US EPA framework, risk characterization in special education should consider:

1) time prediction recovery of a person and his actions after exposure to a stressor, accordingly to the chosen ecosystem;
2) a combination of the different kinds of stressors;
3) critical layer effects; and
4) the quantification of uncertainties.

Risk estimation and risk description are the two steps that make up the risk characterization phase as described next.

Stage 1: Risk estimation

The risk estimation step involves the data integration of exposure and effects, and an uncertainty analysis. During this stage, calculations are made to assess and estimate the risk. Because risk is a probability of the effects of a stressor, it cannot be directly measured. Consequently, risk will be computed from specific events, by using a known and estimated type of uncertainty and the models used to estimate the risk's value. Data integration of the exposure and its effects derived from the conclusion profile of the second phase will lead to an estimate of an expected layer effect or the identification of an exposure exceeding a threshold of significant effects. As shown by Suter's framework, the elements to be considered in a risk estimation account are: the concentration of the stressor, the duration of exposure, the response ratio of the individual(s), and the severity of the effect. In addition, risk estimation requires researchers to consider the described and quantified uncertainties of the preceding phase. This means that the measurement's goals, and the temporal constraints, as well as the data limitations need to be taken into account when a method is being selected or approaches sought to estimate risk. Uncertainty analysis and identification of safety factors are at the core of this risk estimation process.

Uncertainty analysis entails the identification and quantification of uncertainty in the overall ecological risk assessment . Ideally, it should allow one to put forth recommendations for ways to reduce the uncertainty. Uncertainties identified during the measurement phase will allow us to specify safety factors that can then be explored in this risk characterization phase. These factors are then considered when examining the concentration of a stressor, leading to a criterion or a safety standard. Safety factors depend on the exposure and effects to a stressor. The more the ecological effects are irreversible, the greater the safety factors. A safety criterion is the level of a stressor exposure (concentration and duration) in a setting, resulting in a low acceptable effect for the individual(s). A safety standard is directly derived from the safety criteria; it is the limitation of the level of exposure to a stressor manageable in a precise setting.
Inspired by Dubois (1999), three layers of risk can then be specified:

1) acceptable risk, where the person manifests efficient adaptation within a time range;
2) tolerable risk, where monitoring is necessary or the design of an intervention to decrease its potential effect; and
3) unacceptable risk, where the risk exceeds the tolerable threshold of a person and impedes them from adapting efficiently.

Stage 2: Risk description

Analogously to US EPA framework's ecological significance component, this second stage of the risk characterization phase entails the presentation of a synthesis of the results and their interpretation. Specifically, it should include a summary of the risk estimation identified in the previous stage, and a description of the risk magnitude of the assessment endpoint meaning the interpretation and the reflection about the collected data during the ecological risk assessment . When interpreting the data of the risk estimation which depends upon the types and the extent of the anticipatory effects, the following needs to be considered :

1) The nature and the magnitude of the effects - the relative signification of effects, their magnitude, and their probability of occurrence in consideration with their endpoints. For example, even with a low probability of exposure, a stressor could have devastating effects;
2) The spatial and temporal patterns of the effects. For example, a stressor can act on a small scale while having ravaging effects.

The potential for recovery once a stressor is removed or alleviated, while regarding the stressor's nature, duration and extent. During this stage, one should also consider possible other ecological components of the system. In sum, the potential for recovery refers to the counterbalance of the damages made to an ecosystem.
Because this process is intended to guide decision makers and managers, professional judgement is essential during the risk description stage. The results need be clearly presented and interpreted.

Discussion
This article described a first adaptation of an ecological risk assessment framework from the sciences for special education, based on a synthesis of the frameworks put forth by the US Environmental Protection Agency (1995) and Suter (1993). We proposed a theoretical adaptation of the first phase of the framework for intellectually disabled individuals in educational settings. Further adaptations need to be explored with more diverse populations such as behaviourally disordered youth or learning disabled students in educational settings.

The quantitative phase of the framework's application to special education is still to be settled with social science statisticians, in order to ensure the applicable of the calculations used in other fields to the field of special education.
That is, a statistical model needs to be developed for special education while the whole framework discussed also needs to be further tested and evaluated We believe the field of special education could be enriched by frameworks like those used in other scientific fields, such as ecotoxicology to achieve ecological risk assessment or risk analysis, and to help decision makers such as politicians, managers, and educators in their actual decision making process when trying to identify potential solutions.

We also believe that an application of the framework in special education would then lead other fields in the social sciences to explore the usefulness of such an ecological approach. It could then become interesting to compare the risk factors or the obstacles identified for human development with those in special education. This framework could also be used to compare and improve the classification system of *at-risk youth* in social science studies, and aid concerned politicians, managers, and decision makers with the conception and development of better options or solutions. Intervention programs developed for these youths could then be enhanced or re-thought, even leading to prevention. However, an ecological risk assessment study in special education, or in any field of the social sciences for that matter, is not intended to replace studies designed to promote a better understanding of an individual's learning or functioning in diverse settings. Instead, it is intended to add to our understanding of individuals' development from an ecological perspective.

REFERENCES

Algozzine, K.M., Morsink, C.V., & Algozzine, B. (1986). Classroom Ecology in Categorical Special Education Classrooms : And so They Counted the Teeth in the Horse! *The Journal of Special Education, 20* (2), 209-217.
Apter, S.J. (1977). Applications of Ecological Theory : Toward a Community Special Education Model. *Exceptional Children, 43,* 366-373.
Ballard, K.D. (1986). Child Learning and Development in Context : Strategies for Analyzing Behaviour-Environment Interactions and a Proposal for Research into Everyday Experiences. *Educational Psychology, 6* (2), 123-137.
Beckwith, D. (1984). *A Research Methodology for Studying the Learner as a Total System : A Conceptual Paper*. Dallas, TX : Paper presented at the Annual Meeting of the Association for Educational Communications and Technology.

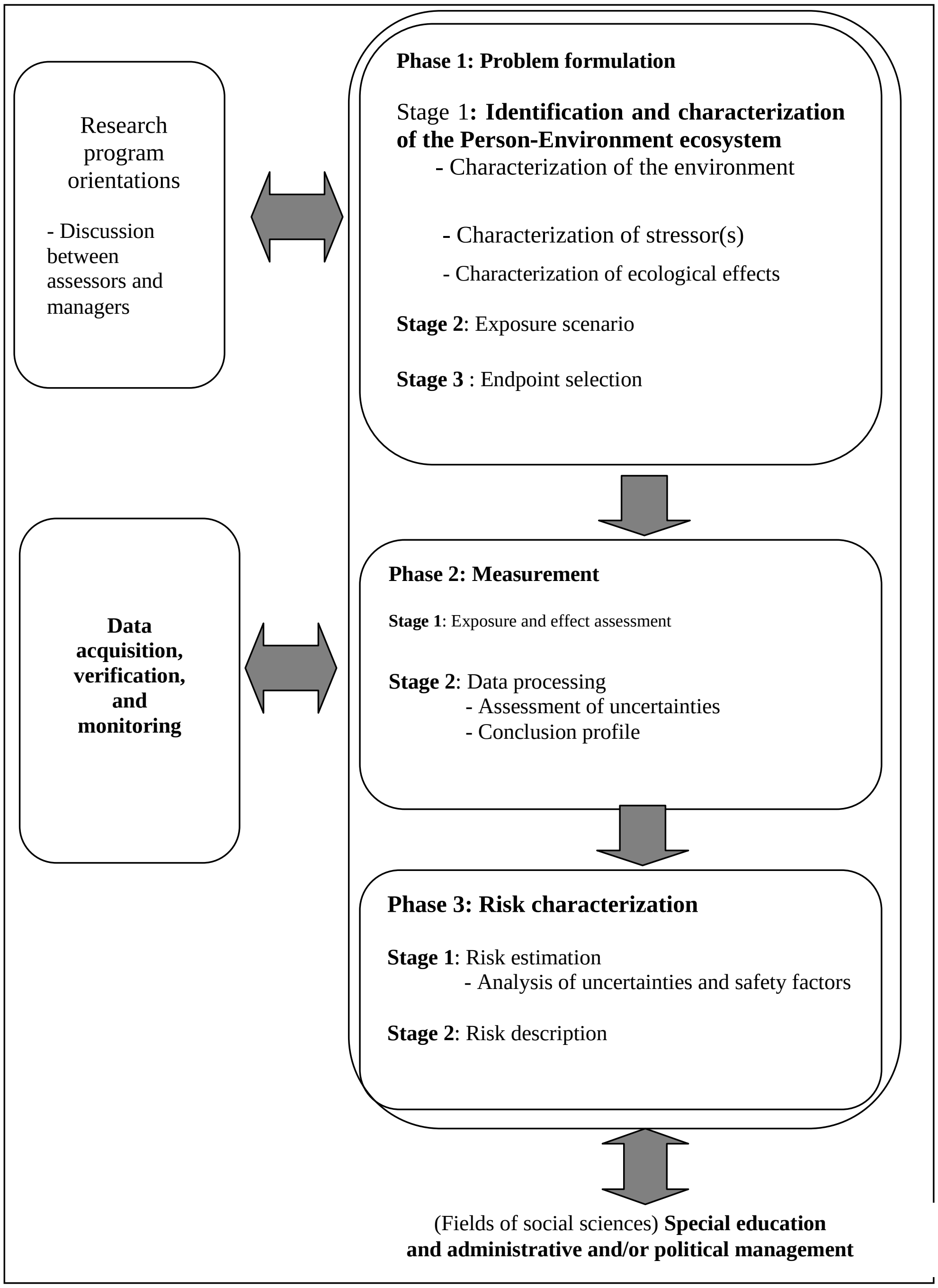

Figure 1: Ecological risk assessment framework in special education

Bronfenbrenner, U. (1996). Le modele «Processus-Personne-Contexte-Temps» dans la recherche en psychologie du developpement : principes, applications et implications. In R.Tessier & G.M. Tarabulsy (Eds.), *Le modele ecologique dans l'etude du developpement de l'enfant* (p. 9-59). Quebec : Presses de l'Universite du Quebec.
Bronfenbrenner, U. (1993). The Ecology of Cognitive Development : Research Models and Fugitive Findings. In R.H. Wozniak, & K. Fisher (Eds.), *Thinking in Context* (pp. 3-44). Hillsdale, N.J. : Erlbaum.
Bronfenbrenner, U. & Ceci, S.J. (1993). Heredity, Environment, and the question "How?" – A First Approximation. In R. Plomin & G.E. McClearn (Eds.), *Nature, Nurture, and Psychology* (pp. 313-324). Washington, D.C. : APA Books.
Cairns, J. Jr. (1995). Restoration Ecology and Ecotoxicology. In D.J. Hoffman, B.A. Rattner, G.A. Burton, & J. Cairns Jr. (Eds.), *Handbook of Ecotoxicology* (pp. 717-731). Boca Raton, FL : CRC Press.
Cairns, J. Jr. & Niederlehner, B.R. (1995). Predictive Ecotoxicology. In D.J. Hoffman, B.A. Rattner, G.A. Burton, & J. Cairns Jr. (Eds.), *Handbook of Ecotoxicology* (pp. 667-680). Boca Raton, FL : CRC Press.
Calabrese, E.J., & Baldwin, L.A. (1993). *Performing Ecological Risk Assessments.* Chelsea : Lewis Publishers.
Centre d'expertise en analyse environnementale du Québec (CEAEQ) (1998). *Procédure d'évaluation du risque écotoxicologique pour la réhabilitaiton des terrains contaminés.* Québec : Ministère de l'Environnement et de la Faune, Gouvernement du Québec.
Cronbach, J.L. (1991). Emerging Views on Methodology. In T.D. Wachs, & R. Plomin (Eds.), *Conceptualization and Measurement of Organism-Environment Interaction*i (pp. 87-104). Washington, D.C. : American Psychological Association.
Delandsheere, V. (1986). In. S. Rocque (1994). *Conception, Elaboration et Validation theorique d'un scheme conceptuel de l'ecologie de l'education.* Montreal : Unpublished doctoral dissertation presented at Universite du Quebec a Montreal.
Dubois, C. (1999). *Deux premieres etapes du prototype d'une echelle de vulnérabilite des personnes presentant des incapacites intellectuelles.* Montreal : Unpublished master degree dissertation of the Faculte des sciences de l'education de l'Universite de Montreal.
Forbes, T.L. & Forbes, T.L. (1994). *Ecotoxicology in Theory and Practice*. London : Chapman & Hall, Ecotoxicology series.
Fraser, B.J., & Fisher, D.L. (1983). Use of Actual and Preferred Classroom Environment Scale in Person-Environment Fit Research. *Journal of Educational Psychology, 75* (2), 303-313.
Holl, K.D., & Cairns, J. Jr. (1995). Landscape Indicators in Ecotoxicology. In D.J. Hoffman, B.A. Rattner, G.A. Burton, & J. Cairns Jr. (Eds.), *Handbook of Ecotoxicology* (pp. 185-197). Boca Raton, FL : CRC Press.
Krebs, C.J. (1989). *Ecological Methodology.* New York : Harper & Row Publishers.
Landis, W.G., & Yu, M.-H. (1995). *Introduction to Environmental Toxicology. Impacts of Chemicals upon Ecological Systems.* Boca Raton, FL : CRC Press.
Legendre, R. (1988). *Dictionnaire Actuel de l'Éducation.* Boucherville : Larousse.
McCall, R.B. (1991). So Many Interactions, So Little Evidence. Why? In T.D. Wachs, & R. Plomin (Eds.), *Conceptualization and Measurement of Organism-Environment Interaction*i (pp. 142-161). Washington, D.C. : American Psychological Association.
Nevin, A., & Thousand, J. (1987). Avoiding or Limiting Special Education Referrals : Changes and Challenges. In M.C. Wang, M.C. Reynolds, & H.J. Walberg (Eds.), *Handbook of Special Education : Research and Practice. Vol. 1. Learner Characteristics and Adaptive Education* (pp. 273-286). Oxford : Pergamon Press.
Norton, S.B.; Rodier, D.J.; Gentile, J.H.; Troyer, M.E.; Landry, R.B., & Van der Schalie, W. (1995). The EPA's Framework for Ecological Risk Assessment. In D.J. Hoffman, B.A. Rattner, G.A. Burton, & J. Cairns Jr. (Eds.), *Handbook of Ecotoxicology* (pp. 703-716). Boca Raton, FL : CRC Press.
Odum, E.P. (1971). *Fundamentals of Ecology.* Philadelphia : W.B. Saunders Company.
Osenberg, C.W., & Schmitt, R.J. (1996). Detecting Ecological Impacts Caused by Human Activities. In C.W. Osenberg, & R.J. Schmitt (Eds.), *Detecting Ecological Impacts. Concepts and Applications in Coastal Habitats* (pp. 3-16). San Diego, CA : Academic Press.
Plomin, R. & Hershberger, S. (1991). Genotype-Environment Interaction. In T.D. Wachs, & R. Plomin (Eds.), *Conceptualization and Measurement of Organism-Environment Interaction*i (pp. 29-43). Washington, D.C. : American Psychological Association.

Rogers-Warren, A., & Wedel, J.W. (1980). The Ecology of Preschool Classrooms for the Handicapped. In J.J. Gallagher (Ed.), *Ecology of Exceptional Children. New Directions for Exceptional Children* (pp. 1-24). San Francisco : Jossey-Bass.

Rutter, M. & Pickles, A. (1991). Person-Environment Interactions: Concepts, Mechanisms, and Implications for Data Analysis. In T.D. Wachs, & R. Plomin (Eds.) *Conceptualization and Measurement of Organism-Environment Interactioni* (pp. 105-141). Washington, D.C. : American Psychological Association.

Salomon, G. (1992). New Challenges for Educational Research: Studying the Individual within Learning Environments. *Scandinavian Journal of Educational Research, 36* (3), 167-182.

Sirotnik, K.A. (1984). An Outcome-Free Conception of Schooling: Implications for School Based Inquiry and Information Systems. *Educational Evaluation and Policy Analysis, 6* (3), 227-239.

Sroufe, L'A., & Egeland, B. (1991) Illustration of Person-Environment Interaction from a Longitudinal Study. In T.D. Wachs, & R. Plomin (Eds.) *Conceptualization and Measurement of Organism-Environment Interaction*i (pp. 64-84). Washington, D.C. : American Psychological Association.

Stewart-Oaten, A. (1996). Goals in Environmental Monitoring. In C.W. Osenberg, & R.J. Schmitt (Eds.), *Detecting Ecological Impacts. Concepts and Applications in Coastal Habitats* (pp. 17-27). San Diego, CA : Academic Press.

Suter, G.W. (Ed.) (1993). *Ecological Risk Assessment*. Michigan : Lewis Publishers.

Suter, G.W. (1993a). Predictive Risk Assessment of Chemicals. In G.W. Suter, (Ed.), *Ecological Risk Assessment* (pp.49-88). Michigan : Lewis Publishers.

Suter, G.W. & Barnthouse, L. (1993). Assessment Concepts. In G.W. Suter (Ed.), *Ecological Risk Assessment* (pp. 21-48). Michigan : Lewis Publishers.

Trépanier, N. (1999). *Reseau fonctionnel d'analyse du risque en milieu d'intervention auprès de personnes vulnérables.* Montreal : Unpublished doctoral dissertation from the Departement de psychopedagogie et d'andragogie of the Faculte des sciences de l'education de l'Universite de Montreal.

U.S. Environmental Protection Agency (1992). Appendices. In W.G. Landis, & M.-H. Yu (Eds.), *Introduction to Environmental Toxicology. Impacts of Chemicals Upon Ecological Systems*. Boca Raton, FL : CRC Press.

Wachs, T.D. (1991a). Synthesis : Promising Research Designs, Measures and Strategies. In T.D. Wachs, & R. Plomin (Eds.) *Conceptualization and Measurement of Organism-Environment Interactioni* (pp. 162-182). Washington, D.C. : American Psychological Association.

Wachs, T.D. (1991b). Environmental Considerations in Studies with Nonextremes Groups. In T.D. Wachs & R. Plomin (Eds.), *Conceptualization and Measurement of Organism-Environment Interaction*i (pp. 44-67). Washington, D.C. : American Psychological Association.

Wachs, T.D. & R. Plomin (Eds.) *Conceptualization and Measurement of Organism-Environment Interaction*. Washington, D.C. : American Psychological Association.

Willems, E.P. (1977). Relations of Models to Methods in Behavioral Ecology. In H. McGurk (Ed.), *Ecological Factors in Human Development* (pp. 21-36), Amsterdam : North Holland Publishing Company.