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Understanding women's empowerment using an exploratory mixed-methods index

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Abstract

Empowerment is a multi-dimensional and contextually nuanced construct, which poses measurement challenges. An important feature of indices is their ability to summarize multi-dimensional information into a single measure. However, the key limitation of indices is their inability to capture complex aspects that are best captured by qualitative methods. This article explores the development of an empowerment index using mixed-methods data in the context of a female scientist's empowerment program to explore the relationship between program activities and empowerment, as well as participant demographics and empowerment. The article seeks to draw conclusions that will inform the design of indices for measuring women's empowerment at the individual level in research contexts.

Key words Empowerment measurement, Women's empowerment, index development, science capacity

Introduction

Empowerment as a construct is understood and applied in different social structures, multiple areas of life (e.g. economic, socio-cultural, familial/interpersonal, legal, political, and psychological) and at different levels (e.g. individual, household, community, country). Individual empowerment – an abstract, multidimensional construct – is defined and expressed in a variety of ways. Based on a range of definitions (e.g. Sen, 1989; Alkire & Ibrahim, 2007; Kabeer, 2001), individual empowerment can be understood in any of the following ways—the exercise of multiple aspirations or goals based on values and sense of responsibility and with respect to well-being; ability to make choices and control over the choice-making process; and, capabilities to pursue goals that improve well-being. The multidimensionality of empowerment implies that it cannot be fully understood by a single measure or indicator, and the nuanced often subjective nature of its components imply that it cannot most effectively be measured by a single methodology.

A deep and nuanced understanding of empowerment thus calls for the use of several indicators and mixed-methods approaches. For example, Bhattacharya and Banerjee (2013) critique the use of autonomy as the sole indicator of empowerment and attempt to supplement autonomy with other dimensions, like health and knowledge, in measuring the empowerment of adult women in West Bengal, India. In a different context Kraimer, Sibert and Liden (1999) examined the empowerment of nurses in the United States using four empowerment dimensions: meaning, competence, self-determination, and impact. Their study found that the four empowerment dimensions differentially related to organizational commitment and career intentions, providing evidence for the predictive validity of the empowerment scale scores. From a methodological

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perspective, Pereznieto and Taylor (2014) reviewed 70 evaluations of development interventions that had direct or indirect impacts on the economic empowerment of women and girls. In concluding their review, they recommended the use of mixed (quantitative and qualitative) methods to assess economic empowerment comprehensively and the use of multiple relevant indicators to measure the economic empowerment of women and girls.

These complexities present measurement challenges to programs working to enhance empowerment, including the empowerment of individuals. Overcoming these challenges through rigorous yet innovative approaches to measurement and analysis of empowerment outcomes is necessary for such programs to demonstrate their value and impact.

It is within this context that the African Women in Agricultural Research and Development (AWARD) program decided to develop and test an empowerment index based on its vast mixed-methods database as an exploratory exercise to investigate the potential value of using an index to understand the contribution of program activities to empowerment and to differentiate the value of the program offerings to different subgroups in the program.

The AWARD Program was conceptually designed based on a portfolio of successful activities initiated and managed by the former Gender and Diversity Program of the Consultative Group for International Agricultural Research (CGIAR). The program is a custom-made two-year career development program for female scientists working in agricultural research and development, comprising of three key components namely; science, mentoring and leadership development. The program offers a range of activities, including formal training, a personal mentor and the opportunity to join a professional association, attend a scientific conference during the fellowship period. Fellows with a Master's or Doctoral degree are also afforded the opportunity to compete for a limited number of advanced scientific placements (with the option of either a short intensive course, or a longer placement of three to six months).

This article explores the development of this exploratory empowerment index and provides a set of analyses to investigate the potential usefulness of the index within the program to assess the impact of various programmatic activities on empowerment. The article also provides reflections on the usefulness of mixed-methods data for index development.

Literature Review

The value of indices and their shortcomings

An indicator is a quantitative or a qualitative measure derived from data points that can be used to demonstrate relative position. When evaluated at regular intervals, an indicator can point out the direction of change across different units and through time (OECD, 2008).

A composite indicator is formed when individual indicators are compiled into a single measure based on an underlying model. Composite indicators typically measure multidimensional concepts that cannot be captured by a single indicator e.g. resilience, competitiveness or empowerment (OECD, 2008). Constructed as a mathematical model, indices rely on complex calculations using statistical tools. Sets of individual indicators in an index are weighted based on their importance with indicators of higher importance assigned more weight and vice versa. Experts determine weighted values of the various indicators in an index (Pintér 2013).

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Indices are one of several tools in the measurement tool box and their use should be selected based on the appropriateness of the situation and research/evaluation question at hand. They have advantages, as well as shortcomings. When indices are used inappropriately, they present several disadvantages. They may send misleading policy messages if poorly constructed or misinterpreted; they may invite simplistic policy conclusions; the selection of indicators and weights could be the subject of (political) disputes or they may lead to inappropriate policies if dimensions of performance that are difficult to measure are ignored. Further, traditional indices may not be suited for complex dimensions that are better studied with qualitative methods (OECD, 2008).

When used appropriately, indices provide many measurement benefits. These include among others, the ability to: identify trends and draw attention to emerging issues; facilitate setting policy priorities for benchmarking or monitoring; and summarize complex, multi-dimensional realities with a view to supporting decision makers. Indices also reduce the visible size of a set of indicators without dropping the underlying information base; and promote accountability (OECD, 2008). Through their reduction of multidimensionality into a single number, they are easier to interpret compared to a several separate indicators enabling improved communication with the general public (e.g. citizens, media, etc.).

The use of indices for understanding women's empowerment

The use of multi-dimensional composite indicators (indices) to measure women's empowerment is a common practice. Alkire and Ibrahim (2007) proposed a set of internationally comparable indicators for measuring women's empowerment at the individual, community and national levels, and within the justice, political, service delivery, and market sectors. Similarly, the Hunger Project uses a Women's Empowerment Index (WEI) that is designed to measure progress in the multi-dimensional aspects of women's empowerment. The dimensions include: agency, income, leadership, resources, and time (the Hunger Project, 2015). Similarly, the IFPRI/USAID Women's Empowerment in Agriculture Index (WEAI) is the first to measure the empowerment, agency, and inclusion of women in the agriculture sector, and the roles and extent of women's engagement in the agriculture sector in five domains: decisions about agricultural production, access to and decision-making power over productive resources, control over use of income, leadership in the community, and time use (IFPRI 2012).

Two major global instruments used to indicate the gender gap in socioeconomic and political development are the Gender Development Index (GDI) and the Gender Empowerment Measure (GEM). The GDI measures inequality in achievement between women and men, related to the overall achievement in a society, life expectancy, educational attainment and adjusted real income. The GEM measures women's political, economic and social participation, including women's representation in parliaments, women's share of positions classified as managerial and professional, women's participation in the labor force and their share of national income (Charmes & Wieringa, 2003).

Although each of the above mentioned indices focus on women's empowerment, none seek to include indicators or develop an index of women's empowerment in the domain of science, nor in the domain of agricultural science.

One problem with the use of indices in the context of empowerment is that, being typically

survey-derived, they rely on deductive, survey-based information in which a respondent has to select from a number of pre-determined responses. Below is an example of one question aimed at gauging individual leadership and influence in the community:

Box 1: Example of typical quantitative survey question

Question:
Do you feel comfortable speaking up in public to help decide on infrastructure (like small wells, roads, water supplies) to be built in your community?
Response options:
No, not at all comfortable 1
Yes, but with a great deal of difficulty 2
Yes, but with a little difficulty 3
Yes, fairly comfortable 4
Yes, very comfortable 5

Although such survey questions will normally include an option to specify what's not predetermined, they suffer the risk of "boxing" the respondent in a set of responses. Complex information is fragmented into a set of conditions and responses must fit into predetermined response categories.

Understanding a complex and contextually nuanced construct like empowerment could be better understood by including a qualitative component that allows for the collection of data is that unencumbered by predetermined tick boxes. This allows researchers to generate deeper information that describes empowerment from the stand point of the women and their experiences (Chung *et. al*, 2013).

Noticing the absence of an index to measure the empowerment of female scientists, and considering the extensive nature of its longitudinal data set, the AWARD program decided to explore the development of a multi-method index for measuring female scientist's empowerment. The remainder of this article discusses the development of a mixed-methods, multi-dimensional index for measuring empowerment of African women in science.

Methodology

Developing the African Women in Science Empowerment (AWSEM) Index: process and components

Data collection and preparatory analysis

Data for the development of the index and the exploratory analysis was drawn from two already existing primary sources, (i) qualitative data collected from fellows after participation in the programme, and (ii) quantitative management information data that provided information on demographics and activity participation.

Qualitative data collected from fellows came from a range of sources – most notably the final

fellowship evaluation form (which includes both qualitative and quantitative questions) and impact story forms which specifically asked fellows to reflect on the changes they had experienced during the fellowship. The integration of these sources of data was used as the data set for deductive coding against the theory of change framework. A detailed description of this process can be found in Noordeloos (2015).

After initial coding, qualitative stories related to each expression of power were assigned a credibility rating of either compelling**,** convincing or lackluster (see Box 2). A compelling impact story gives more than one verifiable and precise example of the change that was brought about through participation in the program. A convincing story gives at least one verifiable example of change indicating that the program has contributed. To ensure that stories were rated appropriately, qualitative data were carefully examined for examples where fellows attributed their growth directly to the program without being prompted to do so. Thus, the program was attributed with influencing change only when participants used phrases such as *"due to my involvement in AWARD"* or *"because of AWARD",* or referred to their participation in a particular program activity.

Box 2: Rating rubric for the evidence per expression of power for each fellow

Compelling
The narrative as a whole reflects a real belief in, even passion about, the content. It gives more than one verifiable and preferably precise example of the change that was brought about (or one overwhelmingly convincing story), and gives a clear indication that AWARD has contributed.
Convincing
The narrative as a whole reflects change in a convincing, although not necessarily inspiring, manner. It gives at least one verifiable example of change, indicating or suggesting that AWARD has contributed.
Lackluster
The narrative as a whole is not convincing. It does not give clear, verifiable examples, and/or does not connect change to AWARD's influence. It may appear to "parrot back" what was said in courses or elsewhere.

The convincing and compelling stories (see Box 2) were categorized as credible evidence of change in a specific expression of power, translating the rating into a binary variable of "credible evidence for change" or "no credible evidence of change".

Using the Dedoose mixed-methods analysis tool, binary code application data at the individual fellow level was exported into Excel for integration with quantitative data. The data was matched at the individual level with the quantitative questions from fellow evaluation forms and the data from the management information system to conduct the analysis.

Conceptualizing the index

The program sought to explore the value of a multi-dimensional empowerment index that encapsulates the range of outcomes expressed within its theoretical empowerment framework in a single measure without having to select some variables and ignore others. However, the index

needed to consider the nuanced perspectives that emerged in the program's qualitative database, not only quantitative indicators.

The purpose of index development was to initiate a thought process on how to develop an exploratory index and use it to test several research questions related to program effectiveness. The process was not intended to yield a psychometrically rigorous tool during this initial phase of development, rather to explore the potential value of such an index and, based on this initial assessment, to consider avenues to further refine and develop the index.

Table 1: Empowerment framework: Expressions of power and associated outcomes

Expression of Power		Outcomes associated with the expression of Power
Power from within		Enhanced vision and direction for a purposeful career Increased self-confidence Increased motivation Increased self-knowledge
Power to do	Access	Better access to contacts and networks Better access to opportunities Better access to information and knowledge
	Research capabilities	Better capability to conduct and publish research Capacity to conduct gender-responsive research Capacity to fundraise for research Present research work in multiple forums
	Leadership capabilities	Better capacity to leverage team talents Better capacity to manage conflict Better capacity to mentor Better capacity to negotiate Better capacity to network Better capacity to present oneself professionally Better capacity to navigate diversities
Power over		Career progress Educational attainment (degrees enrolled for or obtained) Increased professional recognition
Power with		Increased participation in collective activities Increased leadership in collective activities
Power to empower		Increased action to raise awareness of women's contributions to ARD Increased action to strengthen capacities for gender responsive ARD Increased action to influence institutional norms, policies and strategies

The indictors which make up the index are based on the conceptual theory of change framework developed by the program. The framework recognizes five different expressions of power, each of which relates to several outcomes. The five expressions of power and their associated outcomes are described in Table 1.

Each outcome associated with an expression of power was weighted according to its relative importance to the overall expression of empowerment (values of 2 or 3 were assigned to each sub-dimension, depending on its relative importance). If an individual participant had credible evidence for an outcome, they were assigned the full number of points assigned to the outcome. The points assigned to each outcome of a specific expression of power were subsequently summed to represent an indicator score for that expression of power.

Each expression of power corresponded to one or more of the indicators in the composite index, as indicated in Table 2. The 'Power to do' was divided into three indicators, seeing that it represented three conceptual domains. The five expressions of power are thus represented by seven indicators. Fellows who did not provide credible evidence of change for an expression of power were not assigned any points for that indicator.

Prior to calculating the composite empowerment index, scores on each of the indicators were Z-transformed for comparison purposes, since the numbers of outcomes under each indicator were not constant. The composite empowerment index was then calculated by averaging the Z-scores across all seven indicators.

Table 2: Seven indicators of the composite index

Expression of Power	Index	Proportion of total
Power from within	Inner change indicator	(10 points) 14%
Power to do	Access indicator	(9 points) 13%
	Research capabilities indicator	(12 points) 17%
	Leadership capabilities indicator	(18 points) 25%
Power over	Control indicator	(12 points) 17%
Power with	Community indicator	(4 points) 6%
Power to empower	Champion indicator	(6 points) 8%
Composite / AWSEM index		(71 points) 100%

Research questions

The impact of various program activities on the composite empowerment index and its component indicators, were tested through answering the following research questions:

1. To what extent did participation in activities presented through the program influence empowerment in the areas defined by the five expressions of power, as measured via the seven indictors?
2. To what extent did the mentoring component of the program influence fellows' empowerment in the areas defined by the five expressions of power, as measured via seven indicators?
3. To what extent did the geographic region where fellows obtained their qualifications influence their empowerment in the areas defined by the five expressions of power, as measured via the seven indicators?
4. To what extent did the age categories fellows fell under whilst studying for their postgraduate qualifications influence their empowerment in the areas defined by the five expressions of power, as measured via the seven indicators?
5. To what extent did each of the factors mentioned in points one to four above, as well as the demographic factors "age during Bachelor's degree" and "age at start of fellowship", influence fellows' empowerment as measured via the overall composite empowerment index?

Data analysis

Data from 249 fellows from four cohorts of program participants (2008-2011) were available for analysis. Due to extensive missing data, a score on the composite index could not be computed for one of the fellows. Thus, analysis was conducted for a total of 248 fellows.

As noted earlier, due to the number of dimensions falling under each of the expressions of power not being equal, scores on the seven indicators were standardized through Z-transformation to ensure that all are on the same scale. A fellow's standardized score on an indicator therefore represented how many standard deviations above or below the mean for that indicator the fellow scored. Finally, an overall index of empowerment was calculated by averaging the standardized scores across the seven change indicators. This resulted in a single score per fellow that could be interpreted as the average number of standard deviations they scored above or below the mean across the seven indicators, and represents an overall index of change per fellow. The standardized scores were used for all statistical analyses.

Descriptive statistics were calculated for all indicators and the composite empowerment index, as well as for all categorical variables used as predictors of empowerment.

Four factorial multivariate analysis of variance (MANOVA) statistical tests were carried out to test research questions one through four, with scores on each of the empowerment indicators used as dependent variables in all four MANOVA's. The independent variables used as predictors of the empowerment indicators for the four research questions were:

Research question one: Conference attendance and type of conference combined into a single variable which included categories for "Did not attend a conference" as well as for the different types of conferences attended; selection for advanced science training; and completion of the role modelling event.

Research question two: Satisfaction with the frequency of contact with mentors; the degree to which mentoring was seen as beneficial; and mentor gender.

Research question three: Geographic region where Master's degree was obtained and geographic region where Doctoral degree was obtained.

Research question four: Age of fellows during completion of their Master's degree and age of fellows during completion of their Doctoral degrees.

Research question five which aimed to measure the influence of all the above independent variables, as well as fellows' age during their Bachelor's degrees and at the start of the fellowship, on the composite empowerment index, was tested by means of a generalized linear model (GLiM). The probability distribution was specified as Normal with an Identity link function. The GLiM is a generalization of the commonly used general linear model (GLM), which includes multiple regression and analysis of variance, to allow for the analysis of outcome variables for which the errors in prediction (residuals) are not normally distributed (Coxe, West & Aiken, 2013). Due to certain questions only being applicable to fellows with Master's or Doctoral degrees, missing data presented a challenge in the model. To overcome this, the missing data were modelled into the analysis by being included as a category for all variables.

The composite empowerment index was entered as the dependent variable in the model. The independent variables entered were mentor age and gender, Master's degree geographic region, Doctoral degree geographic region, age of fellows during their Bachelor's, Master's and Doctoral degrees, age of fellows at the start of the fellowship, satisfaction with the frequency of mentor contact, how beneficial mentoring has been, type of conference, selection for advanced science training and completion of the role modelling event. As a means to test for interaction effects between independent variables which the researchers thought might play a role, the following interaction effects were included in the model: age during Master's degree X age during Doctoral degree; Master's degree geographic region X Doctoral degree geographic region; mentor age X how beneficial mentoring has been; mentor age X mentor gender; mentor gender X how beneficial mentoring has been.

Post-hoc tests were requested for categorical independent variables with more than two categories, with a Bonferroni correction applied to control for inflated Type 1 error rate due to multiple comparisons.

Results

Descriptive statistics

Descriptive statistics in the form of frequencies for all demographic variables can be seen in Table 3. It should be noted that for the variables that related to postgraduate degrees, the missing

data category includes fellows who have not yet obtained the degree – for example in the case of the Doctoral degree variables all fellows with Master's and Bachelor's level qualifications are included in this category. This approach was necessary in order to conduct the appropriate statistical tests.

Table 3: Descriptive statistics for demographic variables

Demographic variables		Frequency	Percent	Valid percent
Master's degree geographic region	African / National	156	62.9	73.9
	International	55	22.2	26.1
	Missing	37	14.9	
Doctoral degree geographic region	African / National	78	31.5	66.7
	International	39	15.7	33.3
	Missing	131	52.8	
Age at start of fellowship	20 to 29	60	24.2	24.5
	30 to 39	94	37.9	38.4
	40 and older	91	36.7	37.1
	Missing	3	1.2	
Age during Bachelor's degree	19 to 23	94	37.9	38.7
	24 to 28	111	44.8	45.7
	Older than 28	38	15.3	15.6
	Missing	5	2.0	
Age during Master's degree	20 to 25	21	8.5	14.2
	26 to 31	85	34.3	57.4
	Older than 31	42	16.9	28.4
	Missing	100	40.3	
Age during Doctoral degree	30 to 34	15	6.0	22.7
	35 to 39	27	10.9	40.9
	40 and older	24	9.7	36.4
	Missing	182	73.4	

Descriptive statistics for participation in program activities – namely type of conference, participation in advanced science training (based on competitive selection process open to fellows with Master's and Doctoral degrees only) and the completion of the role modelling event can be seen in Table 4 below.

Table 4: Fellow participation in fellowship activities

Participation variables		Frequency	Percent	Valid percent
Type of conference	African / National	55	22.2	22.2
	International conference	85	34.3	34.3
	None	108	43.5	43.5
Selected for advanced science training	Yes	88	35.5	35.6
	No	159	64.1	64.4
	Missing	1	0.4	
Completed role modelling event	Yes	154	62.1	62.3
	No	93	37.5	37.7
	Missing	1	0.4	

Descriptive statistics for the variables related to the mentoring component can be seen in Table 5 below.

Table 5: Frequency distribution mentoring variables

Mentoring variables		Frequency	Percent	Valid percent
Mentor age	30 to 49	58	23.4	58.6
	50 and older	41	16.5	41.4
	Missing	149	60.1	
Mentor gender	Male	115	46.4	46.7
	Female	131	52.8	53.3
	Missing	2	0.8	
Mentor contact frequent enough	Not frequent enough	46	18.5	21.6
	Just right	166	66.9	77.9
	Too frequent	1	0.4	0.5
	Missing	35	14.1	
How beneficial mentoring was	Not beneficial	3	1.2	1.4
	A little beneficial	8	3.2	3.8
	Moderately beneficial	35	14.1	16.6
	Very beneficial	165	66.5	78.2
	Missing	37	14.9	

It is important to note that for the age of the mentor, there was a large amount of missing data, and that for the extent to which mentoring was perceived to be beneficial a large proportion of fellows indicated 'Very beneficial'. This thus limits the variability in the dataset, which has implications for statistical analysis. A similar pattern is noted for the frequency of contact with the mentor.

Results Research Question 1: Three-way MANOVA testing fellow participation in program activities as predictors of empowerment indicators

A three-way MANOVA was run to see whether selection of fellows for the advanced science training program, the type of conference attended by fellows (including a category for no conferences attended) and completing the role modelling event were significantly associated with fellows' scores on each of the empowerment indicators. The three-way MANOVA also tested all possible two-way interaction effects between the participation variables.

There were no significant interaction effects between any of the independent variables on the combined dependent variable ($p > 0.05$), which consists of a statistical combination of all the independent variables. A non-significant interaction effect on the combined dependent variable means that none of the interaction terms significantly predicted scores on any of the empowerment indicators if controlling for multiple comparisons. This result indicates that the effect of any one of the independent variables (selection of fellows for the advanced science training program, the type of conference attended by fellows and completing the role modelling event) on any of the empowerment indicators, did not depend on any of the other independent variables.

However, statistically significant main effects on the combined dependent variable were found for selection of fellows for advanced science training $F(7, 224) = 4.427; p < 0.05; Wilks' \Lambda = 0.878; Partial \eta 2 = 0.122$, and type of conference attended $F(14, 448) = 2.798; p < 0.05; Wilks' \Lambda = 0.846; Partial \eta 2 = 0.080.$

Further investigation into which of the empowerment indicators specifically were influenced by fellows being selected for advanced science training, revealed that selection of fellows for advanced science training had a statistically significant effect on the

- Research capabilities indicator $F(1, 230) = 18.305; p < 0.05, partial \eta 2 = 0.074;$
- the Leadership capabilities indicator, F$(1; 230) = 9.595; p < 0.05; partial \eta 2 = 0.040$, and;
- the Community indicator; $F(1, 230) = 6.248; p < 0.05; partial \eta 2 = 0.026.$

From Table 6 below it is seen that fellows who were selected for advanced science training showed significantly higher mean index scores for all three of the above indices than fellows not selected.

Table 6: Selected for AST: Descriptive statistics scores for statistically significant indicators

				95% Confidence Interval	
Dependent Variable		**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
Research Capabilities Index	No	-0.185	0.087	-0.358	-0.013
	Yes	0.399	0.106	0.190	0.609
Leadership Capabilities Index	No	-0.110	0.089	-0.286	0.065
	Yes	0.321	0.108	0.107	0.535
Power with/community index	No	-0.140	0.091	-0.319	0.039
	Yes	0.215	0.110	-0.003	0.432

This finding is in line with expected results and the desired outcomes of the advanced science program for individual fellows. The intensive nature of the advanced science training exposes fellows to diverse and leading research contexts where they can advance their own knowledge and skills in science. Given that the placements are typically within labs and contexts outside of the fellow's current networks, these placements give fellows the opportunity to develop new collaboration (associated with the community Indicator). The theory of change links the capacity to leverage networks to the leadership capacities index, and it is thus likely that this is the pathway through which the advanced science training contributes to leadership development. Another component of the leadership indicator is the capacity to navigate diversity. Fellows in international placements have the advantage of exposure to diverse contexts, which is an indirect benefit of this component of the program. Although a costly component of the program, the benefits fellows accrue from participating in the advanced science training speaks to the very heart of what the program is striving to achieve. This is an important contribution, given that globally women scientists are less likely to collaborate internationally on research than their male counterparts (Elsevier, 2017). It is hypothesized that this opportunity will serve as a catalyst to enable the future career advancement of the participants. Although not done for this specific analysis it would be useful to investigate whether there are differences in patterns of empowerment as a result of the advanced science placements for fellows who have obtained Master's degrees vs. those who have obtained a Doctorate degree.

In addition, further investigation into which empowerment indicators were influenced by the type of conference fellows attended showed statistically significant main effects on the

- Inner Change indicator $F(2, 230) = 4.601; p < 0.05; partial \eta 2 = 0.038;$
- the Access indicator $F(2, 230) = 5.499; p < 0.05;$ partial $\eta 2 = 0.046;$
- the Research capabilities indicator $F(2, 230) = 6.246; p < 0.05, partial \eta 2 = 0.052;$
- and the Leadership capabilities indicator $F(2; 230) = 5.700; p < 0.05; partial \eta 2 = 0.047.$

Multiple comparisons by means of a Tukey HSD test with a Bonferroni correction showed that there were statistically significant differences in the Inner Change Indicator scores only between

fellows who attended an international conference, and fellows who attended no conferences ($p < 0.05$). From Table 7 it is seen that fellows who attended an international conference obtained higher Inner Change Indicator scores than fellows who did not attend any conferences.

These findings suggest that exposure to an international conference is linked to fellows' inner power – including her confidence. At face value this finding may not make sense, however, fellows who are sponsored to attend an international conference are required to present at the conference (which is not the case for fellows who are attending regional or local conferences). The opportunity to present on an international stage is likely serving as a major confidence booster for fellows. Exposure to international academic circles may also play a role in increasing motivation for fellows (another of the Inner Change outcomes). From a programmatic perspective, the program could consider requiring fellows to present either a poster or an oral paper at any conference in order to qualify for conference funding, and where possible encourage fellows to expose themselves to international meetings.

Table 7: Types of conferences attended: Descriptive statistics for statistically significant indices

Dependent Variable		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Power from within index	African/National conference	0.038	0.150	-0.258	0.334
	International conference	0.283	0.118	0.051	0.516
	None	-0.195	0.105	-0.402	0.013
Access index	African/National conference	0.262	0.143	-0.021	0.544
	International conference	0.259	0.113	0.037	0.481
	None	-0.183	0.100	-0.380	0.015
Research Capabilities Index	African/National conference	0.346	0.143	0.065	0.627
	International conference	0.184	0.112	-0.037	0.405
	None	-0.209	0.100	-0.406	-0.012
Leadership Capabilities Index	African/National conference	0.400	0.146	0.114	0.687
	International conference	0.102	0.114	-0.123	0.328
	None	-0.186	0.102	-0.387	0.015
	International conference	-0.134	0.117	-0.364	0.097
	None	-0.029	0.104	-0.234	0.177

For the Access, Research capabilities and Leadership indicators, multiple comparisons showed significant differences only between fellows who attended no conferences and fellows who attended either African/national conferences or international conferences ($p < 0.05$).

For each of the indices, fellows who attended no conferences obtained significantly lower scores than fellows who attended either an African/national conference, or fellows who attended an international conference (Table 7).

Conference participation (regardless of geographic location) is thus associated with important program outcomes. Notably, conferences increase fellow's exposure to networks, information and opportunities (Access index) – this confirms the theoretical pathway in the theory of change and the value of conference sponsorship in the program. The same holds true for the association with research capacities. The association with leadership is likely linked to the outcomes of leveraging networks and/or the capacity to present one's research work professionally in appropriate platforms.

Research Question Two: Three-way MANOVA for testing variables related to mentorship as predictors of empowerment indicators

A three-way MANOVA was run to see whether fellows' satisfaction with the frequency of contact with their mentors, how beneficial mentoring was and mentor gender, were significantly associated with fellows' scores on each of the empowerment indicators. The three-way MANOVA also tested all possible two-way interaction effects between the mentoring variables.

There were no significant interaction effects between any of the independent variables on the combined dependent variable ($p > 0.05$). Thus, none of the interaction terms significantly predicted scores on any of the empowerment indicators if multiple comparisons are controlled for. This result indicates that the effect of any one of the independent variables (fellows' satisfaction with the frequency of contact with their mentors, how beneficial mentoring was and mentor gender) on any of the empowerment indicators, did not depend on any of the other independent variables.

However, a statistically significant main effect on the combined dependent variable was found for fellows' satisfaction with the frequency of contact with their mentors, $F(7, 189) = 2.225; p < 0.05; Wilks' \Lambda = 0.924; Partial \eta 2 = 0.076.$

Further investigation into which specific empowerment indicators were influenced by fellows' satisfaction with the frequency of contact with their mentors showed statistically significant main effects on the Access indicator $F(1, 195) = 4.226; p < 0.05, partial \eta 2 = 0.021$; and the Control indicator $F(1, 195) = 4.466; p < 0.05; partial \eta 2 = 0.022.$

Table 8 shows the difference in mean index scores for each of these indices between fellows who said that mentor contact was not frequent enough or too frequent, and fellows who said it was just right. Fellows who felt that mentor contact frequency was just right showed significantly higher mean index scores for both the above indicators.

Table 8: Frequency of mentor contact: Descriptive statistics for statistically significant indices

Dependent Variable		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Access index	Not frequent enough or too frequent	-0.174	0.136	-0.442	0.094
	Just right	0.172	0.099	-0.023	0.366
Power over/control Index	Not frequent enough or too frequent	-0.282	0.149	-0.577	0.013
	Just right	0.108	0.108	-0.105	0.322

Literature shows (Elsevier, 2016) that access to influential networks is an important pathway for career progress. From this perspective, the significant finding that mentors increase fellows' access to knowledge, networks and opportunities is an important one. The Control Index is linked to both career progress and to educational progress, and qualitative data shows that mentors facilitate this type of empowerment through a variety of pathways. First, they play an important role in helping fellows develop purpose road maps – which map out a fellows' career goals. This process of goal setting enables fellows to focus their careers and often guides them in making important career decisions. The following quote by a fellow from the 2010 cohort illustrates this:

> "Before AWARD, I didn't have a well laid out goal and purpose road map. The mentoring partnership has equipped me with skills of determining where I want to be in life and I have gained confidence because I know what to do in order to achieve my goal"

Secondly, mentors serve as powerful motivators – encouraging fellows to pursue ambitious opportunities or to continue on to higher levels of educational attainment.

> "Making difficult decisions sometimes needs advice from a person one trusts. [My mentor] came into my life close to the end of 2009 when I was making a very difficult decision between stopping to work and enrolling in a PhD programme of my choice. We openly discussed my goals and she encouraged me to go for what I wanted to do at that particular time in my life without fear of the consequences. I had very little funding and hence went ahead without it. Now I am about to complete second phase of my PhD research project" *2009 Cohort fellow with Master's degree*

It is interesting to note that the gender of the mentor does not have a statistically significant influence on any of the empowerment outcomes. The program purposefully decided from its inception to have both male and female mentors; the rationale being that including male mentors could increase their understanding on gender issues in agricultural research and development.

Essentially, the inclusion of male mentors is a possible ripple effect of the program and internal monitoring data confirms this finding. The non-significant impact of mentor gender on the empowerment of fellows confirms that this approach has not been at the disadvantage of the fellows.

It was expected that the perceived benefit of mentoring would be significantly associated with empowerment. The low levels of variability in the data are however likely to influence the extent to which this can be accurately assessed.

When comparing the findings from research questions one and two, it is of value to note how the different components of the fellowship (activity participation and relationship with the mentor) facilitate different types of empowerment. This reinforces the program's theory of change which asserts that the different components of the program work synergistically to achieve a broader range of outcomes than would have been possible with only singular elements of the fellowship.

Research question three: Two-way MANOVA for testing the influence of the geographic region where fellows obtained their postgraduate degrees on the empowerment indicators

There was no statistically significant interaction effect between the geographic regions where fellows obtained their Master's and Doctoral degrees (African / National or international) on the combined dependent variable ($p > 0.05$). Thus, the interaction term between the geographical region where fellows Master's degrees were obtained and the geographical region where fellows' Doctoral degrees were obtained, did not significantly predict scores on any of the empowerment indicators if multiple comparisons are controlled for. This result indicates that the effect of the geographical region where fellows' Master's degrees were obtained on any of the empowerment indicators, did not depend on the geographical region where fellows' Doctoral degrees were obtained, and vice versa.

In addition, neither "Master's degree geographic region", $F(7, 99) = 0.839; p > 0.05; Wilks' \Lambda = 0.944; Partial \eta 2 = 0.056$ nor "Doctoral degree geographic region", $F(7, 99) = 1.115; p > 0.05; Wilks' \Lambda = 0.927; Partial \eta 2 = 0.073$, had a statistically significant main effect on the combined dependent variable. Thus, the geographical region where fellows' Master's degrees were obtained and the geographical region where fellows' Doctoral degrees were obtained did not have a significant impact on any of the empowerment indicators.

Although there were no significant findings associated with the indicators, this variable was in fact significantly associated with the composite index (see Research Question 5 for a further reflection on this).

Research Question Four: Two-way MANOVA for testing the influence of fellows' ages during their postgraduate qualifications on the empowerment indicators

A two-way MANOVA was run to see whether fellows' ages during their Master's and Doctoral qualifications were significantly associated with their scores on each of the empowerment indicators. The two-way MANOVA also tested whether there was a significant two-way interaction effect between fellows' ages during their Master's and Doctoral qualifications, on the

empowerment indicators.

There was no significant interaction effect between fellows' ages during their Master's qualifications and their ages during their Doctoral qualifications on the combined dependent variable ($p > 0.05$). Thus, this two-way interaction did not significantly predict scores on any of the empowerment indicators if multiple comparisons are controlled for. This result indicates that the effect of fellows' ages during their Master's qualification on any of the empowerment indicators did not depend on their ages during their Doctoral qualification, and vice versa.

However, a statistically significant main effect on the combined dependent variable was found for fellows' ages during their Doctoral degree, $F(7, 49) = 2.257; p < 0.05; Wilks' \Lambda = 0.756; Partial \eta 2 = 0.244$. Especially noteworthy here is the effect size of 0.224, indicating a large effect and thus great practical significance of this result.

Further investigation into which specific empowerment indicators were influenced by fellows' ages during their Doctoral degree, showed statistically significant main effects on only the Access index, $F(1, 55) = 11.869; p < 0.05, partial \eta 2 = 0.177$. There are significant differences in Access index scores between fellows who were 30 to 39 (mean = 0.528) during their Doctoral degree, and fellows who were 40 and older during their Doctoral degree (-0.48). Fellows who were 30 to 39 during their Doctoral degree showed significantly higher Access indicators empowerment scores than fellows who were 40 or older during their Doctoral degree.

This is a somewhat unexpected finding, and the interpretation thereof is not immediately evident. One potential explanation is that doctoral candidates who are younger have more flexibility to explore opportunities that come their way than older candidates (post 40) who may be more established. However, this hypothesis would need to be investigated more carefully, as the opposite could also be argued – that fellows in their 30s are more likely to have limitations on their flexibility due to family commitments. Possible confounding factors may be playing an important role. What makes this finding interesting is the large effect size associated with it. The large effect implies a finding of practical significance and it may thus be particularly important for the program to investigate this further.

Research Question Five: Results of the generalized linear model (GLiM) for testing the influence of demographic and program specific factors on the composite empowerment index

A GLiM was run to test the influence of demographic variables, participation variables, mentoring variables, and geographic location of, and age during, postgraduate qualifications variables, on the composite empowerment index. Interaction terms between chosen variables were also included in the model where it was thought that the influence of a specific independent variable might depend on another independent variable.

Results showed that all the independent variables combined statistically significantly predicted scores on the composite empowerment index, $\chi^2(45) = 99.182$; $p < 0.05$. Further investigation into which of the independent variables contributed significantly to this result was conducted by means of Wald Chi-Square tests, testing the effect of each independent variable based on the linearly independent pairwise comparisons among the estimated marginal means of the

independent variable categories. These test results can be seen in Table 9 below.

Table 9: Results Generalized Linear Model

	Wald Chi-Square	df	Sig.
Mentor gender	0.086	1	0.769
Master's degree geographic region	0.712	2	0.700
Doctoral degree geographic region	26.756	2	0.000
Age during Bachelors	0.937	3	0.817
Age during Master's	42.391	3	0.000
Age during Doctoral degree	13.599	3	0.004
Mentor age	3.045	2	0.218
Age at start of fellowship	8.037	3	0.045
Mentor contact frequent enough	7.802	2	0.020
How beneficial mentoring has been	0.510	2	0.775
International or African/national conference	10.901	2	0.004
Selected for Advanced Science training (yes/no)	3.372	1	0.066
Completed role modelling event	0.913	1	0.339
Age during Master's * Age during Doctoral degree	111.598	13	0.000
Mentor age * How beneficial mentoring has been	7.065	8	0.530
Mentor gender * Mentor age	5.080	5	0.406
Mentor gender * How beneficial mentoring has been	4.021	5	0.546
Master's degree geographic region * Doctoral degree geographic region	42.506	7	0.000

**Note: The Wald Chi-Square tests the effect of each independent variable based on the linearly independent pairwise comparisons among the estimated marginal means*

Table 9 shows that there were statistically significant interaction effects on the composite empowerment index between

- Master's degree geographic region and Doctoral degree geographic region, $\chi^2(7) = 42.506$; $p < 0.05$,
- Age during Master's degree and age during Doctoral degree $\chi^2(13) = 111.598$; $p < 0.05$.

However, multiple comparisons by means of a Tukey HSD test with a Bonferroni correction showed that there were no significant interaction effects that did not involve the missing category, for both the interaction between Master's degree geographic region and Doctoral degree geographic region, and the interaction between age during Master's degree and age during

Doctoral degree. Thus, for individuals who had data available for Master's degree geographic region and Doctoral degree geographic region, the two variables did not interact significantly with each other. The same applies for age during Master's degree and age during Doctoral degree.

Due to this lack of significant interaction effects, the main effects for all variables in the model were interpreted. Table 9 above shows that there were significant main effects on the composite index of empowerment for

- doctoral degree geographic region, $\chi^2(2) = 26.756$; $p < 0.05$,
- age during Master's degree, $\chi^2(3) = 42.391$; $p < 0.05$,
- age during Doctoral degree, $\chi^2(3) = 13.599$; $p < 0.05$,
- age at start of fellowship, $\chi^2(3) = 8.037$; $p < 0.05$,
- satisfaction with the frequency of mentor contact, $\chi^2(2) = 7.802$; $p < 0.05$,
- and the type of conference attended, $\chi^2(2) = 10.901$; $p < 0.05$.

For Doctoral degree geographic region, multiple comparisons with a Bonferroni adjustment revealed that there were significant differences in the composite empowerment index scores between fellows who attained their Doctoral degrees in Africa or nationally, and fellows who studied for their Doctoral degrees internationally ($p < 0.05$). Fellows who studied in Africa or nationally obtained higher composite empowerment index (Mean = 0.227) scores than fellows who studied internationally (Mean = -0.483).

Although the researcher was interested in understanding if the geographic location where fellows obtained their degree impacted on the extent to which they benefitted from the fellowship, no directional hypothesis was assumed prior to investigating this, and no programmatic elements have been linked to a rationale that assumes there are differences. Further exploration is required to help understand the underlying factors linked to these differences or to identify other confounding variables that may be influencing the result. Whether this finding has the potential to inform program design should be informed by this further analysis.

For both age during Master's degree and age during Doctoral degree, as well as for age at start of fellowship, multiple comparisons showed that significant differences between the categories were limited to comparisons with the missing categories. There were therefor no significant differences between the age categories for fellows who had data available for either age during Master's degree, age during Doctoral degree or age at start of fellowship.

For fellows' satisfaction with the frequency of contact with their mentors, after adjustment for multiple comparisons, no significant effect on the composite empowerment index scores could be found between any of the categories ($p > 0.05$). The mean composite index empowerment scores for each of the categories can be seen in Table 9 above.

Finally, for the type of conference fellows attended, multiple comparisons with a Bonferroni adjustment revealed that there were significant differences in the composite empowerment index scores between fellows who attended no conferences, and fellows who attended either African / national or international conferences ($p < 0.05$). Fellows who attended either African / national

or international conferences obtained higher composite empowerment index scores than fellows who did not attend any conferences (Table 10). This resonates with the findings from Research Question One, and underpins the value of the conference within the program.

Table 10: Descriptive statistics for composite indicator by conference attendance

			95% Wald Confidence Interval	
	Mean	**Std. Error**	**Lower**	**Upper**
African/National conference	0.0601	0.148	-0.229	0.350
International conference	0.0360	0.138	-0.233	0.306
None	-0.187	0.127	-0.436	0.061

Given that the analysis was of an exploratory nature, the model did not include all program activities or demographic variables. It can thus not be concluded that conferences are the most important component of the fellowship; however, it can be confidently concluded that they play an important role in empowering female scientists – and that international conferences may have additional value for fellows' inner change (i.e. confidence and motivation).

Future analysis can consider investigating which course offerings (leadership training, science writing training and other workshops) contribute to the various indicators and the overall composite index.

Conclusion

While indices have their limitations, especially in relation to complex and context-sensitive phenomena as argued earlier in this paper, they also have advantages; opportunities for their use in empowerment measurement are so prevalent. However, it is necessary is to understand when it is meaningful to apply indices, intersperse our interpretations with needed caveats, and innovate around improving indices strengths and reducing the risks of their limitations.

The exploratory analyses in this article have illustrated the value of indices for confirming theory of change models and for informing program design. The article has also successfully demonstrated how mixed-methods data can successfully be integrated into indices – potentially overcoming one of the inherent challenges of using indices.

Taking these initial findings as a base, the opportunity now exists for further refining the index, possibly considering how the index could be adapted for application outside of the AWARD program as a generalized index for measuring the empowerment of female scientists. This could involve incorporating additional components to the framework borrowing from other indices of women's empowerment reviewed for this paper.

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