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Behavioral studies on children's knowledge of natural phenomena and family learning in the museum

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Author contributions

CHAPTERS IN THIS DISSERTATION AND CONTRIBUTIONS OF CO-AUTHORS

Chapter 2 is based on: Franse, R. K., Van Schijndel, T. J. P., Visser I., & Raijmakers, M. E. J. (2020). *Children's Understanding of Floating and Sinking: Predictions and Explanations Tell Different Stories*. Manuscript in revision.

RF and MR conceived the ideas and designed the study. RF collected the data with the aid of a student. RF and TvS coded the data. RF, MR and IV analyzed the data. RF wrote the manuscript with input of all authors. All authors have approved the final manuscript.

Chapter 3 is based on: Franse, R. K., Van Schijndel, T. J. P., Plankman, T. I., & Raijmakers, M. E. J. (2020). *Families' Manipulations and Conversations at an Open-ended Exhibit in a Science Museum: Individual Characteristics and the Influence of Minimal Guidance Strategies*. Manuscript under review.

RF, MR and TvS conceived the ideas and designed the study. RF and TP collected the data. RF, MR and TvS coded the data with the aid of a student (Mandy Lubbers). RF, MR and TvS analyzed the data. RF wrote the manuscript with input of MR and TvS. All authors have approved the final manuscript.

Chapter 4 is based on: Franse, R. K., Van Schijndel, T. J. P., & Raijmakers, M. E. J. (2020). Parental Pre-knowledge Enhances Guidance During Inquiry-Based Family Learning in a Museum Context: An Individual Differences Perspective. *Frontiers in Psychology, 11*.

RF and MR conceived the ideas. MR designed the study, supervised the data collection and data coding. RF and MR analyzed the data. RF wrote the manuscript with input of all authors. All authors have approved the final manuscript.

Samenvatting

Summary in Dutch

Leren van en over alledaagse wetenschap

Gedragstudies naar de kennis van kinderen over natuurverschijnselen en het leren van families in het museum.

Het onderzoek beschreven in dit proefschrift komt voort uit een interesse in hoe mensen leren van en over alledaagse wetenschap. In drie empirische studies (**hoofdstuk 2, 3 en 4**) zijn verschillende aspecten van dit leren bestudeerd: de kennisrepresentaties die kinderen hebben van natuurverschijnselen (studie 1), het effect van minimale begeleidingsstrategieën op het onderzoekend leren door families bij een interactieve museumopstelling (studie 2) en de impact van ouderlijke voorkennis op de ouder-kind interactie tijdens het onderzoekend leren (studie 3). In het laatste hoofdstuk (hoofdstuk 5) worden de belangrijkste bevindingen van deze drie studies samengevat en worden vervolgens de uitkomsten besproken in relatie tot de wetenschappelijke relevantie, de onderzoeksbeperkingen, de richtingen voor toekomstig onderzoek en de opbrengst voor de museumpraktijk.

SAMENVATTING VAN DE BELANGRIJKSTE BEVINDINGEN

In de eerste studie (**hoofdstuk 2**) hebben we de voorkennis van kinderen over drijven en zinken onderzocht. Kinderen leren over het fenomeen drijfvermogen door middel van verschillende informatiebronnen: fysieke ervaringen, het observeren van specifieke situaties, het lezen van boeken of door gesprekken met anderen. Hoe kennis die voortkomt uit heterogene informatiebronnen wordt georganiseerd (DiSessa, Gillespie, & Esterly, 2004; Vosniadou, 2008) en hoe deze kennis het best kan worden beoordeeld (Straatemeier, Van der Maas, & Jansen, 2008; Van Schijndel, Van Es, Franse, Van Bers, & Raijmakers, 2018b), zijn vragen die in de cognitieve wetenschapsliteratuur aan de orde komen. We onderzochten systematisch de coherentie van de representaties die kinderen hebben van drijfvermogen, in meerdere contexten (sets van objecten) en aan de hand van meerdere taken (een vragenlijst en een gestructureerd interview). Aan kinderen van vier tot twaalf jaar werd gevraagd het drijfvermogen voor drie sets van objecten te voorspellen en het drijfvermogen van de voorspelde drijvers en zinkers te verklaren. De sets van objecten verschilden in drijfvermogengerelateerde kenmerken. Het drijfvermogen van de abstracte objecten (kubussen gemaakt van een mix van materialen) kon alleen worden voorspeld op basis van waarnemingen van de massa en het volume van de kubus. Terwijl het drijfvermogen van de objecten gemaakt van bekende materialen (houten en metalen kubussen) en de typische drijvers en zinkers ook kon worden voorspeld op basis van materiaalkennis en feitenkennis. Met de eerste studie hebben we, binnen en tussen kinderen, meerdere kennisrepresentaties van het drijfvermogen aangetoond, afhankelijk van de taakvereisten en de te classificeren soorten objecten. Door meerdere taken te gebruiken voor het meten van de kennisrepresentaties van kinderen, hebben we laten zien dat verschillende typen vragen verschillende kennisrepresentaties oproepen. Dat wil zeggen, voorspellingsvragen triggeren meer geavanceerde tweedimensionale strategieën (massa + volume) en verklarings-

vragen triggeren minder geavanceerde eendimensionale strategieën (alleen massa). Daarnaast hebben we aangetoond dat voorspellingen en verklaringen niet consistent waren binnen individuen. Door de kennisrepresentaties van kinderen voor meerdere contexten (sets van objecten) te beoordelen, hebben we laten zien dat verschillende objectkarakteristieken verschillende kennisrepresentaties triggeren. Dat wil zeggen, abstracte objecten triggeren regelgebaseerde kennis (één- of tweedimensionale strategieën) en exemplarische voorbeelden triggeren vooral feitelijke kennis. Daarnaast hebben we laten zien dat het voorspellen van het drijfvermogen van objecten gemaakt van bekende materialen (houten en metalen kubussen) een wisselwerking tussen verschillende soorten van kennisrepresentatie triggert.

In de tweede studie (**hoofdstuk 3**) hebben we onderzocht wat het effect is van minimale begeleidingsstrategieën door publieksbegeleiders op het onderzoekend leren van families bij een interactieve opstelling in een wetenschapsmuseum. De effectiviteit van onderzoekend leren en de factoren die bijdragen aan deze effectiviteit, zijn onderwerpen in de literatuur die onderzoekend leren in zowel de formele als informele leeromgeving beschrijft. We gebruikten een experimenteel onderzoeksdesign waarbij families in de controleconditie op eigen kracht onderzochten en families in de experimentele conditie begeleid werden door een publieksbegeleider die een van de twee minimale begeleidingsstrategieën toepaste: het beschrijven van observaties of het geven van uitleg. Een belangrijk verschil tussen de twee begeleidingsstrategieën is dat bij het beschrijven van observaties bijvoorbeeld alleen relevante taakaspecten of waarnemingen worden beschreven, terwijl bij het geven van uitleg het wetenschappelijk correcte causale verband tussen beide wordt benoemd. Familieteamen ($n = 104$) van één ouder en twee kinderen van vier tot twaalf jaar hebben het fenomeen van de objectbeweging onderzocht door experimenten te ontwerpen en uit te voeren die rekening houden met meerdere variabelen. Als indicatoren voor onderzoekend leren observeerden we in detail de manipulaties die de families uitvoerden en de conversaties die de families hadden tijdens het onderzoeken. Het aandeel experimenten waarbij families de strategie van het controleren van variabelen toepasten (CVS-experimenten) werd gebruikt als maatstaf voor de manipulatie-kwaliteit. De conversaties die families voerden tijdens het onderzoeken werden bestudeerd op zowel proces (het formuleren van hypothesen en het interpreteren van de resultaten) als inhoud (het fenomeen objectbeweging en betrouwbare experimenten). Met de tweede studie hebben we aangetoond dat families bij een ‘open-ended’ interactieve opstelling in een wetenschapsmuseum in staat waren om op een zinvolle manier te onderzoeken. Families pasten de strategie van het controleren van variabelen toe bij het ontwerpen van hun experimenten en formuleerden hypothesen en causale verklaringen. Families bespraken niet alleen de inhoud van het experiment (de beweging van cilinders op een helling), maar ook op een meta-niveau de betrouwbaarheid van hun experimenten. Hoewel de manipulaties en de conversaties grotendeels zinvol waren, leidden ze niet noodzakelijkerwijs tot correcte hypothesen en conclusies over het fenomeen: families relateren objecteigenschappen vaak op een wetenschappelijk onjuiste manier aan objectbeweging. We hebben echter aangetoond dat minimale begeleidingsstrategieën toegepast door publieksbegeleiders een positieve bijdrage

kunnen leveren aan het verminderen van wetenschappelijk onjuiste conclusies over de relatie tussen objectbeweging en objectmassa. Dit effect werd aangetoond voor beide minimale begeleidingsstrategieën, d.w.z. het beschrijven van observaties en het geven van uitleg.

In de derde studie (**hoofdstuk 4**) hebben we het effect van ouderlijke voorkennis op de ouder-kind interactie tijdens het onderzoeken onderzocht. Daarnaast hebben we de relatie tussen de persoonskenmerken van ouders en kinderen en de ouder-kind interactie onderzocht. De mogelijke relatie tussen persoonskenmerken van ouders en kinderen enerzijds en effectieve ouder-kind interactie en onderzoekend leren van families anderzijds, is interessant voor zowel onderzoekers (ontwikkelingspsychologie en onderwijswetenschappen) als van museum-professionals. We hebben de interactie van ouder-kind paren (N = 105) met acht- tot twaalfjarige kinderen bestudeerd door ze een zwarte doos te laten onderzoeken, een activiteit die de deelnemers uitnodigt om causale relaties te onderzoeken en modelmatig te redeneren. Als indicatoren voor ouder-kind interactie bestudeerden we de manipulaties van de paren door te observeren wie er handelde (het kind of de ouder alleen, of in samenwerking) en de spraak van zowel ouder als kind op het voorkomen van elementen van wetenschappelijke redeneren en scaffolding (bijv. het stellen van open vragen). Als leeropbrengst van het onderzoeken werd bestudeerd hoe accuraat ouders en kinderen waren in het oplossen van het zwarte doos-probleem. De resultaten van de derde studie toonden aan dat voorkennis van de ouders de ouderbegeleiding faciliteerde, op die manier dat ouders meer gesloten en open vragen stelden. Ouderlijke voorkennis leidde ook tot een toename van het aantal verklaringen van kinderen. Bovendien leidde de voorkennis van de ouders ertoe dat de leerresultaten van de kinderen verbeterden, zonder dat de ouders meer uitleg gaven. We hebben ook aangetoond dat persoonskenmerken van ouders en kinderen gerelateerd waren aan de interactie tussen ouders en kinderen: de samenwerking tussen ouder en kind is verschillend voor ouder en dochter enerzijds en ouder en zoon anderzijds. Het effect van voorkennis op de samenwerking tussen ouder en kind is eveneens anders bij vader en kind en moeder en kind. Daarnaast was de zelfgerapporteerde onderzoekshouding van kinderen gerelateerd aan de spraak van het kind tijdens het onderzoekend leren, op die manier dat kinderen met een meer onderzoekende houding minder gesloten vragen stelden en meer open vragen.

CONCLUSIE

Dit proefschrift is een voorbeeld van gedragsonderzoek in het museum dat gericht is op een beter begrip hoe families leren van en over wetenschap en technologie in een informele leercontext. Als resultaat van drie empirische studies hebben we geleerd dat kinderen verschillende kennisrepresentaties van drijfvermogen hebben, dat minimale begeleidingsstrategieën door publieksbegeleiders invloed hebben op de conclusies die families trekken uit onderzoek en dat ouderlijke voorkennis invloed heeft op hoe ouders hun kinderen tijdens het onderzoeken begeleiden. Deze bevindingen kunnen informatief zijn voor zowel de fundamentele wetenschap als voor de museumpraktijk. Een beter begrip hoe mensen

onderzoekend leren, kan museumprofessionals helpen weloverwogen keuzes te maken tijdens het ontwerpproces van informele leermethodes en kan het denken van museumprofessionals scherpener over wat zij willen bereiken met een tentoonstelling. Daarmee kan een door de wetenschap geïnformeerde praktijk (evidence informed practice) bijdragen aan diepergaande museale leerervaringen.

List of publications

- Franse, R. K., Van Schijndel, T. J., & Raijmakers, M. E. (2020). Parental Pre-knowledge Enhances Guidance During Inquiry-Based Family Learning in a Museum Context: An Individual Differences Perspective. *Frontiers in Psychology, 11*.
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- Franse, R.K., Van Schijndel, T.J.P., Visser I., & Raijmakers, M.E.J. (2020). *Children's Understanding of Floating and Sinking: Predictions and Explanations Tell Different Stories*. Manuscript in revision.
- Franse, R.K., Van Schijndel, T.J.P., Plankman, T. I., & Raijmakers, M.E.J. (2020). *Families' Manipulations and Conversations at an Open-ended Exhibit in a Science Museum: Individual Characteristics and the Influence of Minimal Guidance Strategies*. Manuscript under review.

